

Manned Ground Vehicles (MGV) NDIA Combat Vehicle Symposium

COL Chuck Coutteau and Dick Williams
22 September 2005

Purpose

**The purpose is to provide an overview of the
FCS Program and information on the current
Manned Ground Vehicle design concepts and key
design challenges**

Agenda

- Manned Ground Vehicles Overview
- Best Technical Approach
- Survivability
- Lethality
- Propulsion
- Component Maturation/Reliability
Availability Maintainability (RAM)

Leading Transformation

- The US Army “At War and Transforming”
 - 781,000 to 480,000 active duty since 1990
 - Forces currently deployed in 120 countries
 - Simultaneous current and future “needs”
 - A campaign-quality Army with Joint and expeditionary capabilities
 - Joint *Interdependence* not just Interoperable
 - Expeditionary operations will be the norm



General Peter J. Schoomaker
Chief of Staff, U.S. Army

*General Schoomaker
Congressional Testimony
21 July 2004

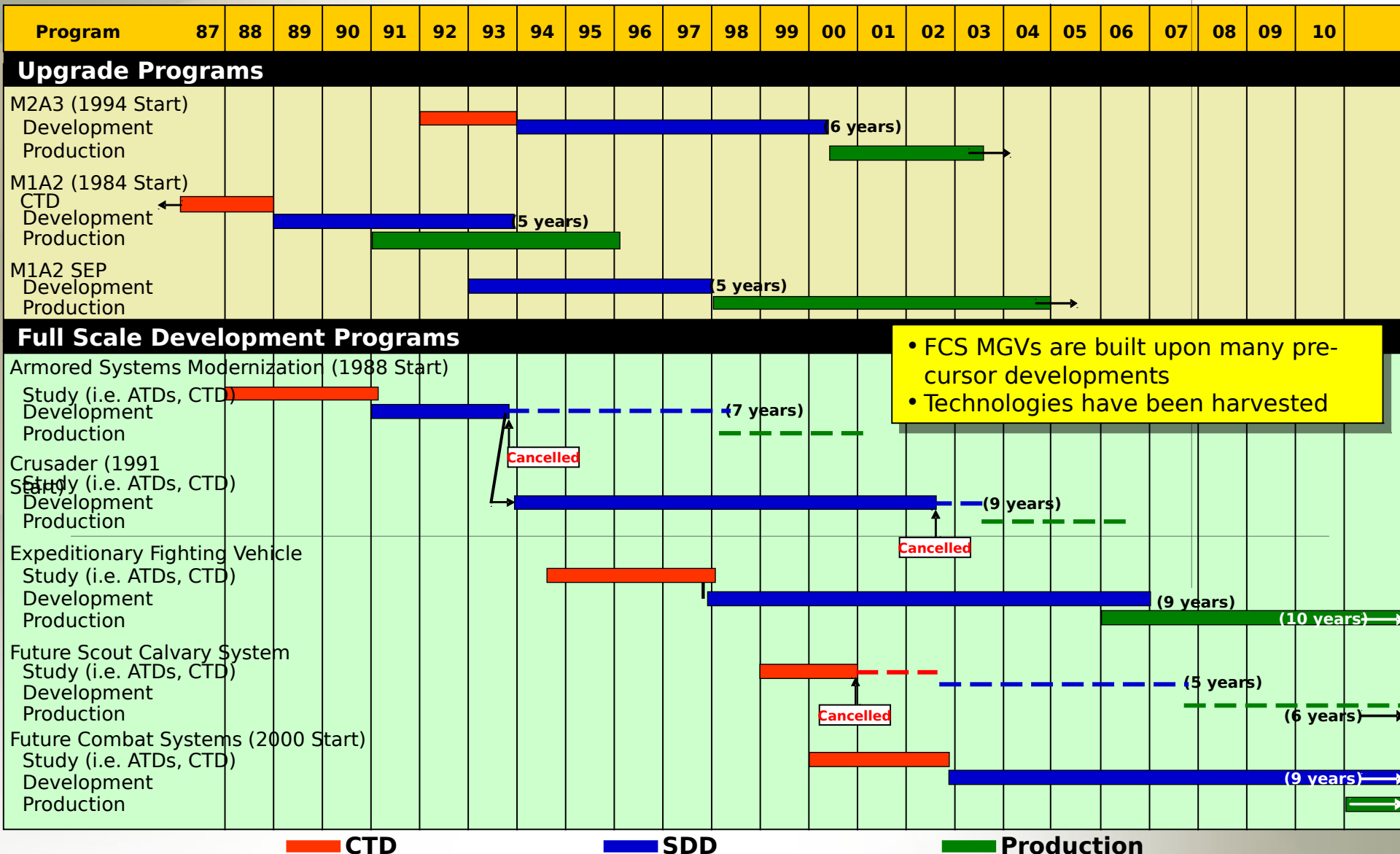
• FCS: Transformation in Multiple Dimensions

**“The best way to anticipate the future is to
business create it!”**

Objective Tiger Video



Historical Perspective of Development Schedules



FCS Development Schedule is Consistent with Past Single Platform Development Programs

FCS MGV Technology Leveraging

FSCS

Crusader

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry
Comanche



- Hybrid Electric Drive
- Band Track
- Active Suspension
- Sensor Mast
- Active Track Tensioner
- Lithium-Ion Batteries
- Crew Station
- Propulsion Control Algorithms
- High-power generator, motor and inverters
- Modular Armor
- Structures & Composites
- Dynamic Physics Models

- Auto Ammo Handling
- Auto Cannon Cooling/Cleaning
- Laser Ignition
- Projectile Tracking System
- Signature Management
- Drive-by-Wire
- Bore Hazard Sensor
- Structures & Composites
- Dynamic Physics Models
- Virtual Integration Lab
- Application Software
- Real-Time Common Operating Environment
- IFTM Authoring System

- Composites
- Titanium Heat Exchangers
- Production Processes & Materials
- Warfighter Machine Interface
- 3rd Gen FLIR
- Performance Based Logistics



Infantry Carrier Vehicle



Reconnaissance and Surveillance Vehicle



NLOS - Mortar Vehicle



Mounted Combat System



NLOS - Cannon Vehicle



Recovery and Maintenance Vehicle

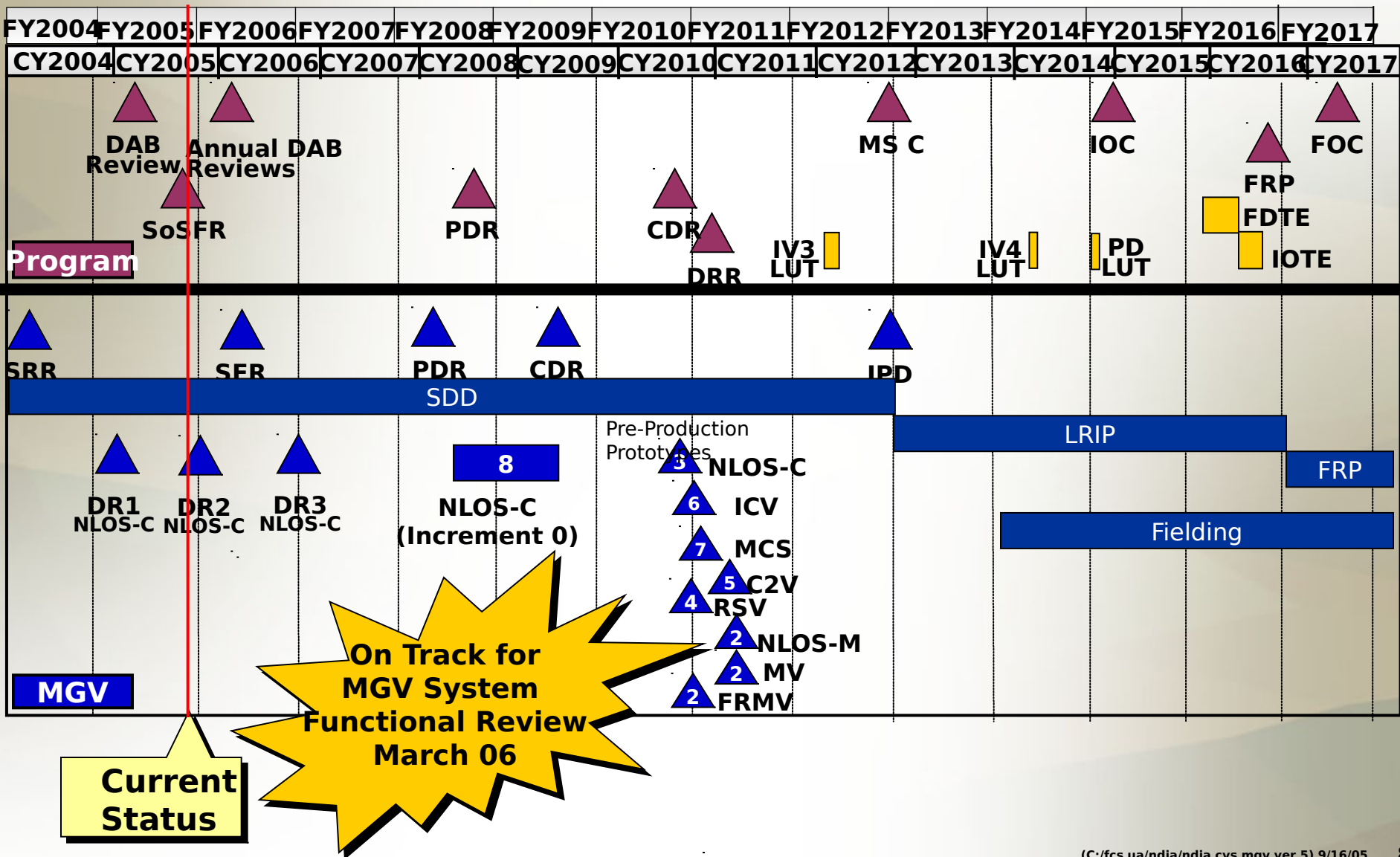


Command and Control Vehicle



Medical Treatment/Evacuation Vehicle

Top Level Schedule (PM UA & MGV Extract)



Common Systems

Propulsion Cooling System

Low Voltage Power Distribution

Environmental Control System

Nuclear Biological Chemical Filtration System

Advanced Man-Machine Interfaces

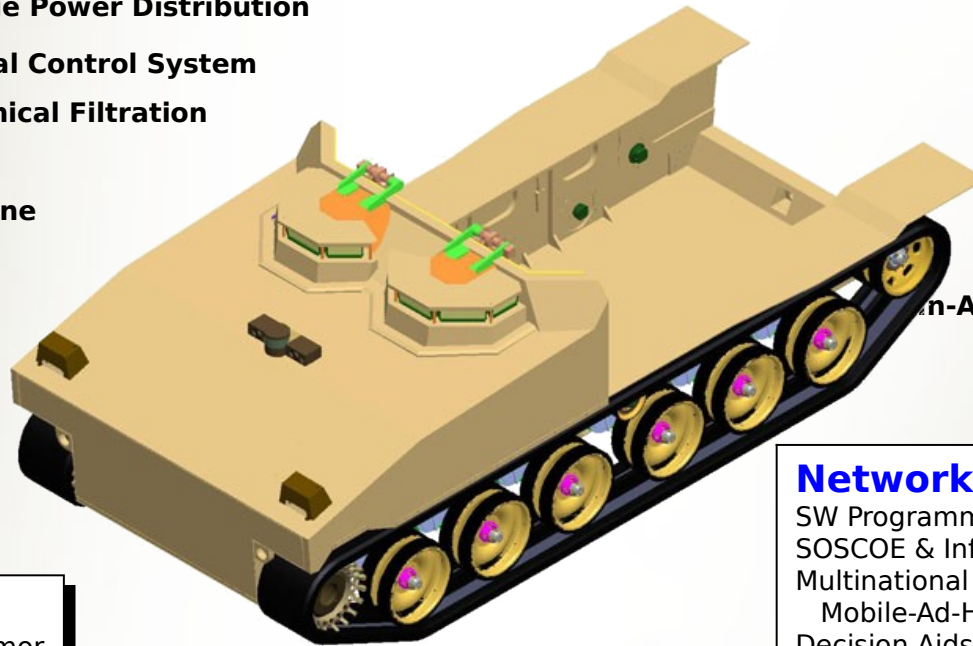
Embedded Predictive Logistics Sensors & Algorithms

High Power Density Engine

Fuel Efficient Hybrid Electric Propulsion

Chassis

Lightweight Hull and vehicle Armor
 Anti-Tank Mine Protection Kit



Signature Management

Power Distribution And Control

High Density Packaged Power

Air Handling Unit

Hydro Pneumatic Suspension

Network

SW Programmable Radio Suite & Antennas
 SOSCOE & Information Exchange - Army Joint Multinational
 Mobile-Ad-Hoc Networking Protocols
 Decision Aids
 Distributive Collaboration of Manned/Unmanned Platforms
 Security Intrusion Detection



Infantry Carrier Vehicle



Reconnaissance & Surveillance Vehicle



NLOS - Mortar Mounted Combat Vehicle



NLOS - Cannon Vehicle



Recovery & Maintenance Vehicle



Command & Control Vehicle



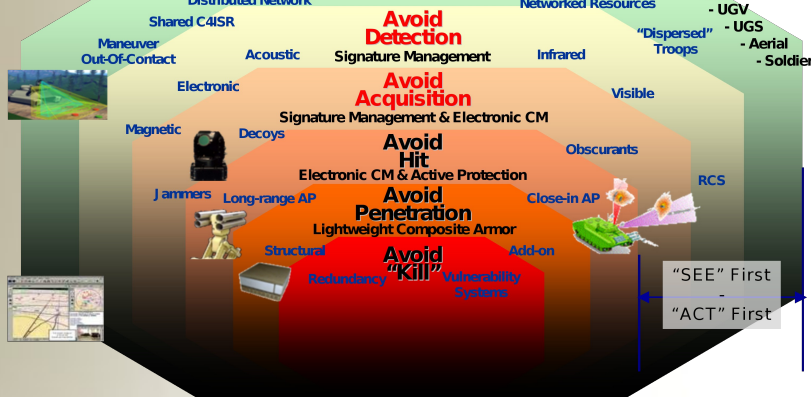
Medical Treatment/ Evacuation Vehicle

70-80% Commonality Reduces O&M Cost
70% of MGCV AUPC on average are common sub-systems

MGVs Provide Networked Lethality and Survivability Within the UA

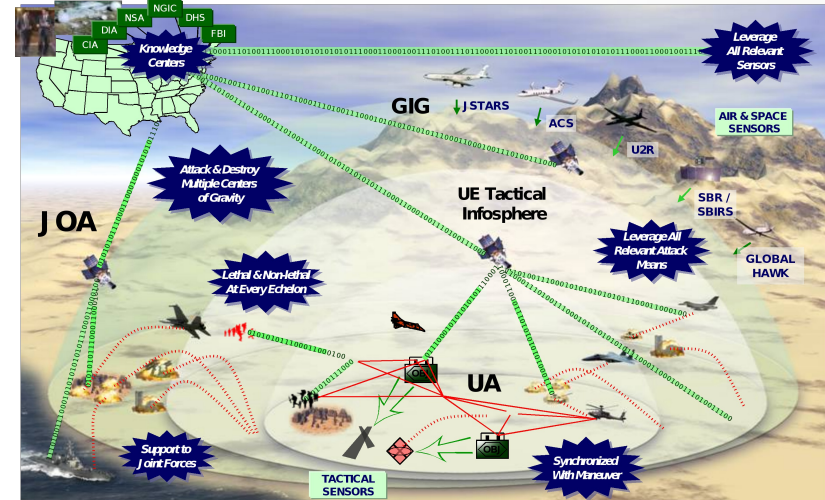
Enabled by Integrated Network

- Distributed Network
- Robust Bandwidth & Range
- Freq. Agile Comms

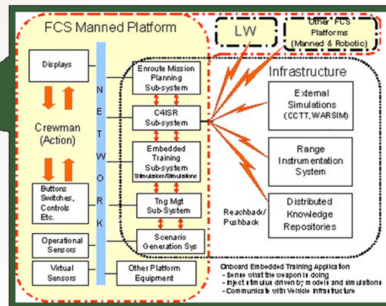


Even if all else fails, the FCS platforms are more survivable than current armored vehicles

Networked Lethality



Networked Training



Objective: Train all individual, crew, collective and leader tasks using *embedded* training on their *assigned* (go to war) *vehicle*.... *Enroute Mission Rehearsal / Planning*...

Networked Supportability

Logistics Concept

- ✓ Network Enabled
- ✓ Performance Based (PBL)
- ✓ Distribution Based
- ✓ Common Operating Picture
- ✓ Anticipatory / Predictive / Reduced Footprint

Maintenance

- Substantially Increased Reliability and Availability
- Maximum Commonality of Components
- Common Electrical Connectors
- Prognostic / Diagnostic Sensors Integral to Platforms and Soldiers
- Immediate Access to Remove / Replace Modular Components
- Interactive Electronic Technical Manuals Embedded on Platforms

Water

- UA Generates its own Water

Fuel

- Lighter Vehicles
- Energy Efficient Drive Train

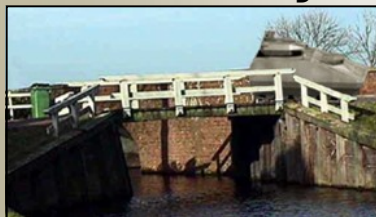
Munitions

- Networked Lethality - Targeting and Firing
- Smart Munitions

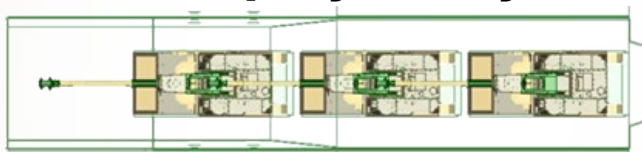
MGV is the Host and Point of Presence for Majority of UA Capabilities

Balancing Capabilities

Mobility



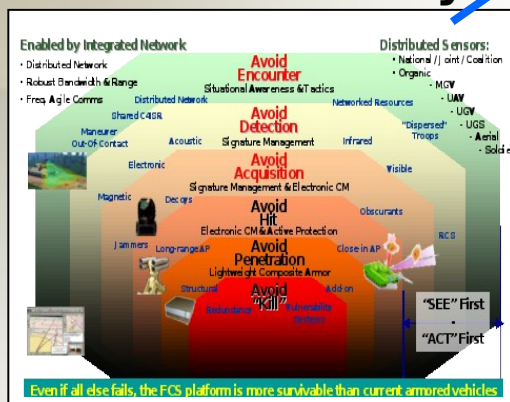
Deployability



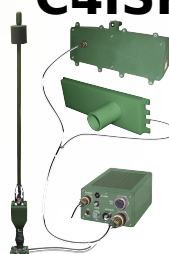
Lethality



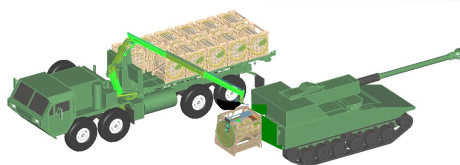
Survivability



C4ISR



Sustainment

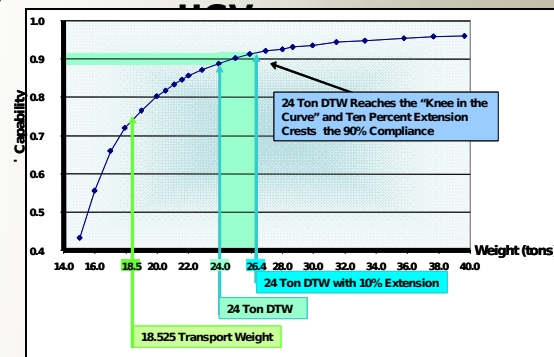


Integrate:

- Soldier
- UAV

Space/Weight/Power

- Training
- Lethality
- MANPRINT
- Comp
- Programs
- Supportability



Convergence of BTA with Requirements will yield Performance Baseline at SFR

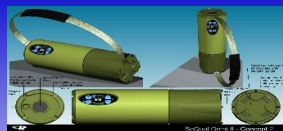
FCS MGV Current Procurements

- Band Track
- Engine
- Traction Drive System
- Environmental Control System
- Energy Storage
- Generator
- Active Protection System
- Energy Dissipater

- High Power Distribution Bus
- Road Arm Assembly
- DC-DC Converter Power Stage
- Crewman Remote Interface System
- Servo Motor Controllers
- MCS 120mm Gun and Ammo Handling System

MGV Commercial Off The Shelf (COTS)

Servo Motors



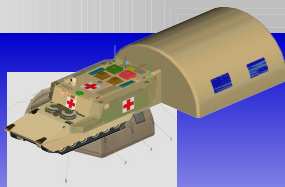
Oxygen Concentrator

Bearings



Blood Refrigerator -
10 Unit Storage Cap.

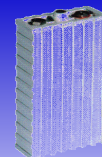
Gear Boxes



MV-T
External Shelter

Solenoids

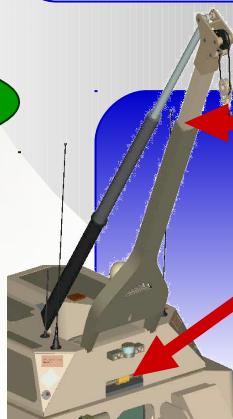
Cooling Fluid
Elect. Valves



Nickel Metal
Hydride Battery

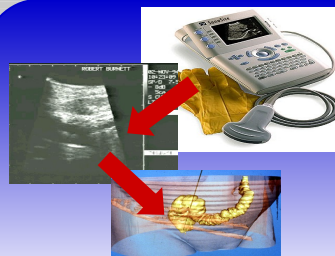
Proximity
Sensors

Electrical
Connectors



Crane
(Deployed
Position)
Main Winch

Cooling
Fluid Manifolds



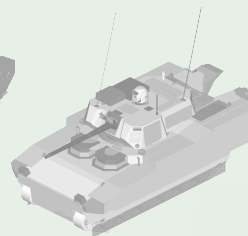
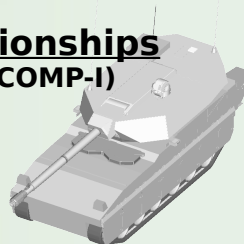
Mission Electronic Motors

This represents
some of the
COTS products
that are being
considered

Complementary Programs with MGV Relationships

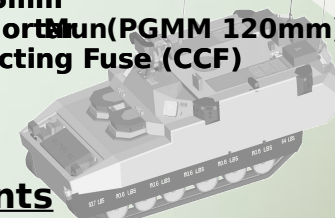
CPs with Other Relationships

Secure Enroute Comm Pkg (SECOMP-I)
Soldier as a System
OneTESS
JTRS Cluster 5
NDL (JTRS waveform)
WNW (JTRS waveform)
SRW (JTRS CL5 waveform)



CPs as Munitions Fired

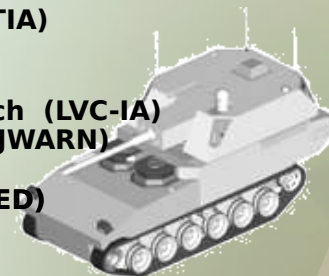
Med Range MRM (MRM) 120mm BLOS
Excalibur 155mm
Nonlethal 155mm
Pre Guided Mun (PGMM 120mm)
Course Correcting Fuse (CCF)



CPs as Installed/Carried Components

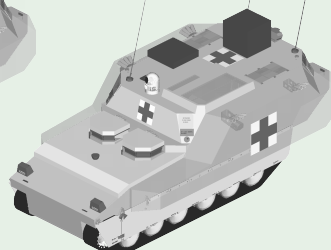
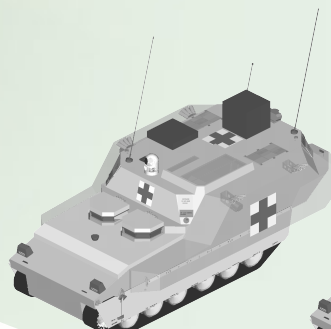
JTRS Cluster 1
Warfighter Information Network Tactical (WIN)
Lt Base Design/Rng (LDR)
Medical Communications (MC4)
ANPSS-14 (HSTAMIDS)
Combat ID
Joint Bio Point Det Sys (JBPDS)
Joint Chemical Agent Detector (JCAD)
Jnt Ser Ltwt Standoff Chem Agt Det (JSLSCAD)

Dist Common Ground Army (DCGS-A)
One Sem Aut Forces (OneSAF)
Common Training Inst Arch (CTIA)
Army Training Info Arch (ATIA)
Synthetic EnviroCore (SEore)
Live Virtual Comb Integrating Arch (LVC-IA)
Joint Warning+Report Network (JWARN)
Battle Command Sys (BCS3)
Common Embed Diagnostic (CED)
Global C2 Sys Army (GCSA)



CPs as Weapons Mounted

ACSW XM307 25mm Cannon
MK44 30/40mm Cannon



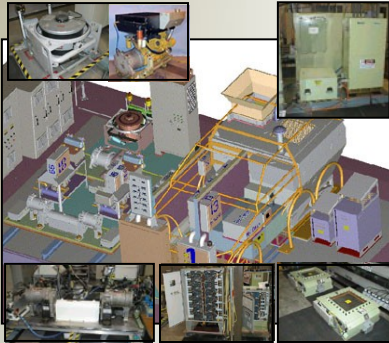
MGV Summary



IAAPS



BAND TRACK



**HYBRID
ELECTRIC TESTING**

- Design Processes On track for MGV SFR (March 06)
- Optimizing Current Concepts to achieve a Balanced Set of Capabilities
- Actively managing our program challenges

MGV is testing hardware today



**SIKA
MAST TESTING**



NLOS CANNON



120MM CANNON

MGV Best Technical Approach

Dan Holtz
Lead System Integrator
MGV Lead Engineer

▪ BTA Objectives

- Conduct trades/analyses to identify system solutions/options that meet SoSS Rev E (ORD 1.2) changes
- Update Common/Variant system concepts and SWAP-C data with possible solutions for customer input
- Develop subsystem solutions/options using system guidance
- Prepare solutions for MGV SFR

▪ BTA Assumptions

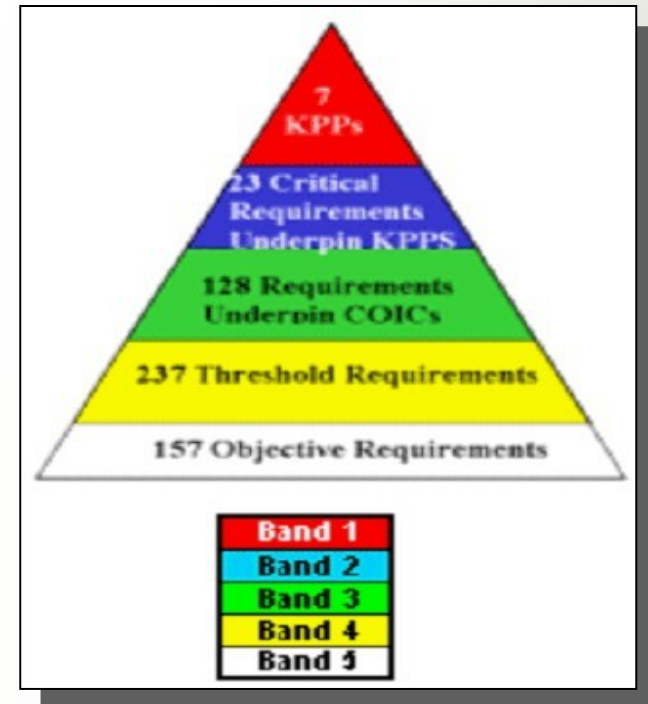
- QFR 11/04 is baseline configuration at 24T DTW
- SoSS Rev E is document used for identification of PIDS gaps

▪ BTA Approach

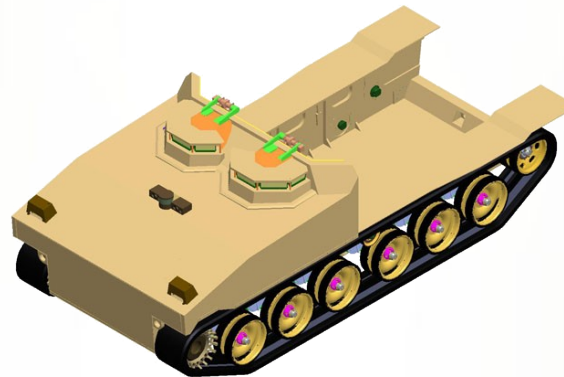
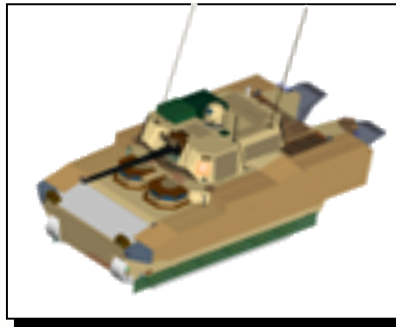
- ✓ Identify PID gaps
- ✓ Establish BTA guidance
- Identify system solutions/options
- Identify subsystem solutions/options
- Communicate solutions/options to user for input

TRADOC Priorities

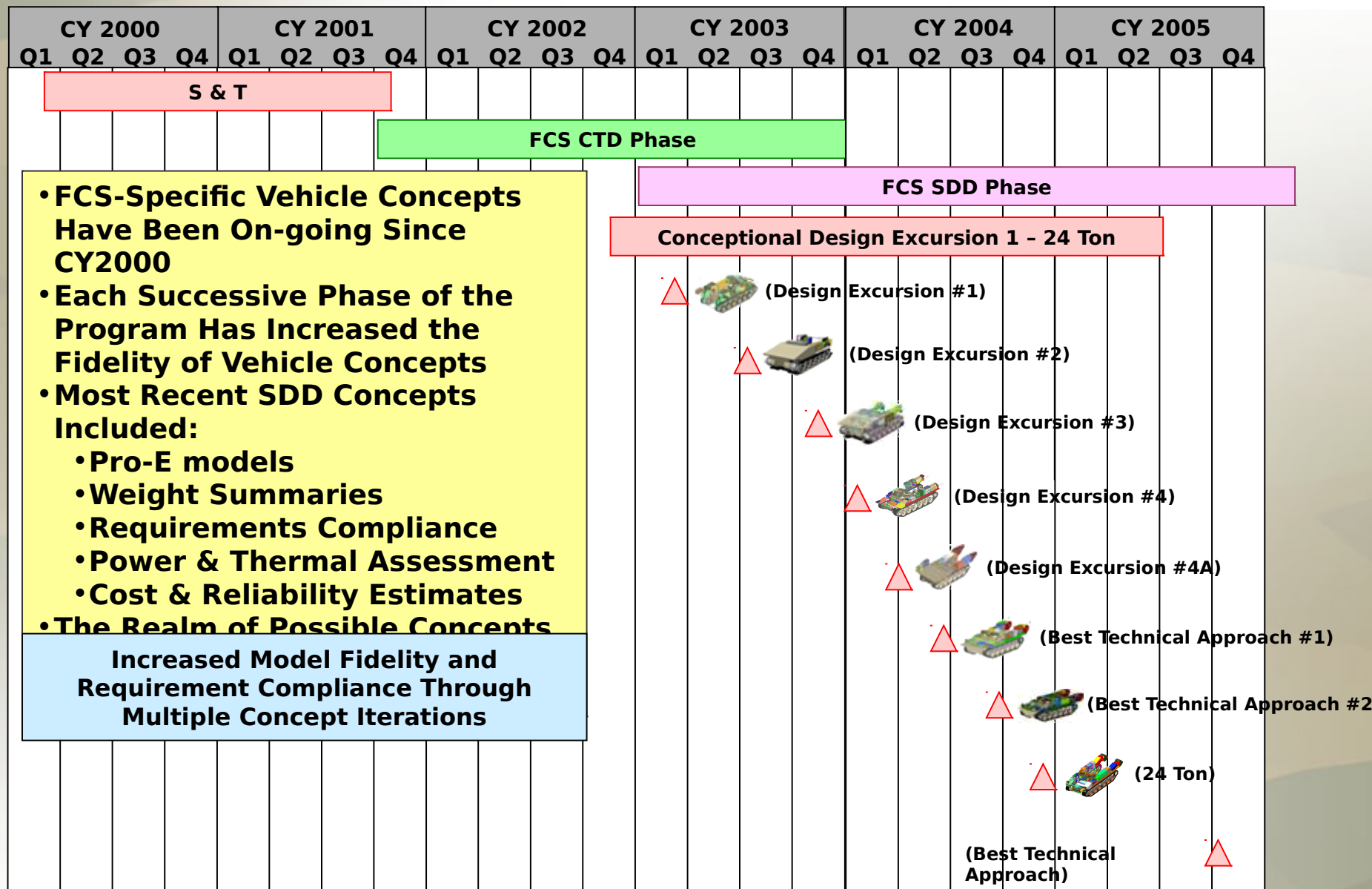
- Initial MGVS Efforts utilized ORD Banding as the primary criteria for prioritization
- When GEN Byrnes issued the TRADOC Priorities, MGVS used them within ORD bands as an additional criteria
- TRADOC Priorities
 - C-130 Transportable
 - Crew Survivability
 - Auto Cannon, HMG, HE Frag, AP
 - Lethality/Mission Equipment
 - Sustainment
 - Ao, Reliability, Resupply
 - Mobility



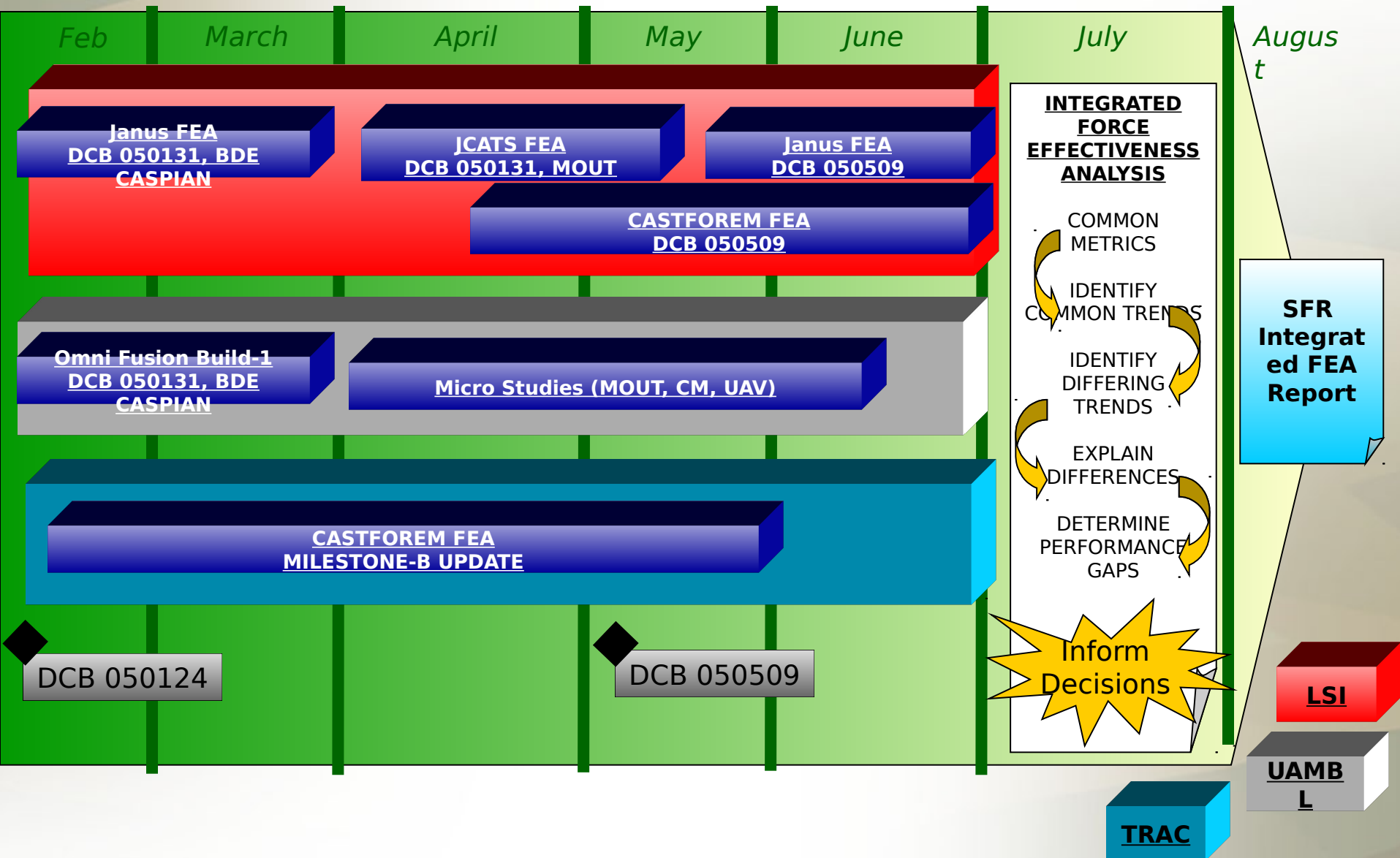
Manned Ground Vehicles Family



Historical Chronology of FCS Vehicle Design



Force Effectiveness Analysis Methodology



Post SoSFR Focus Areas

■ Analysis

- SA/SU on Enemy in Difficult Postures and Hide
- Mine Detection
- Unmanned Vehicle Employment
- Network Capability
- Logistics Footprint and Re-Supply Concept

Exploring full use of SoS, TTPs, and our analysis tools to ensure full understanding of DCB capabilities and potential performance improvements

Funding

- Lethal and Non-Lethal Munitions

Materiel

- AT Mine Protection
- Gap Crossing

Some specified lethal and non-lethal munitions included in the DCB and related analyses are not funded

IPTs evaluating design alternatives

To meet System SFR and SoSIPDR needs

Manned Ground Vehicles

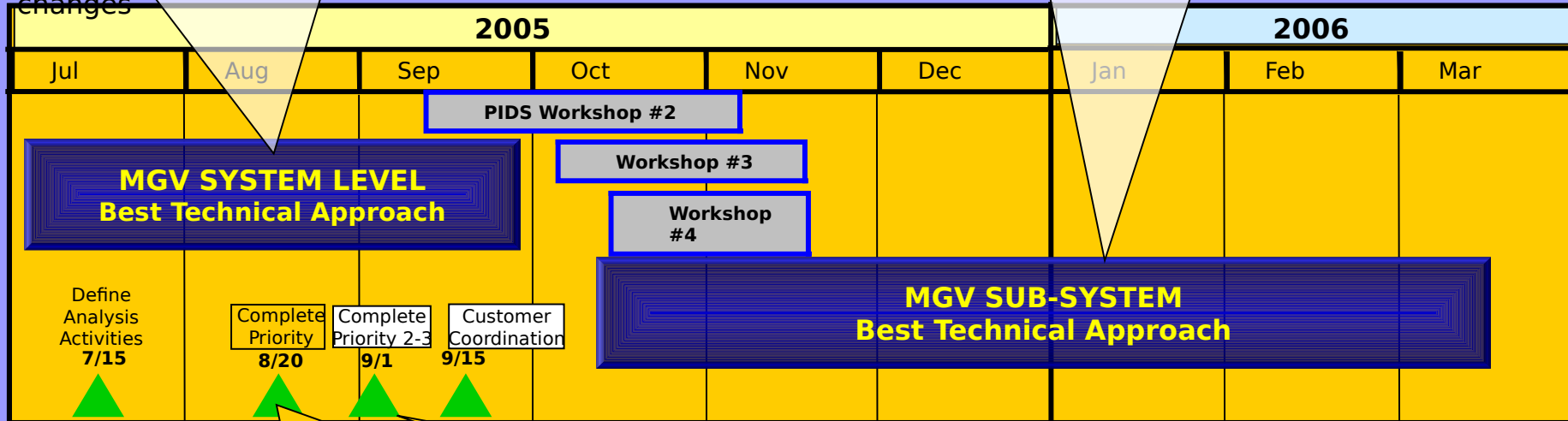
Best Technical Approach Objectives

Objectives

- Move variant baseline toward compliance with Jan. '05 ORD
- Resolve inter-related competing space claims
- Establish Variant Zones
- Obtain Customer Concurrence for Variant Concept changes

Objectives

- Obtain balanced approach at sub-system
- Establish SWAP-C and Design to cost targets



High Priority Analysis

- Engine compartment
- Low-Profile Crew Station
- AT Mine Protection
- A&B Armor Solution
- Mission Critical Ballistic Protection
- Engine Exhaust/ Cooling
- Crew hatches

Second Group of Analysis

- Internal Fuel Volume
- Suspension (12" - 8" of request)
- Spall Protection
- Split NBC Solution
- Sub-System SWAP-C
- Hull Structure (Alum. vs. Ti)

Balance

Communicate

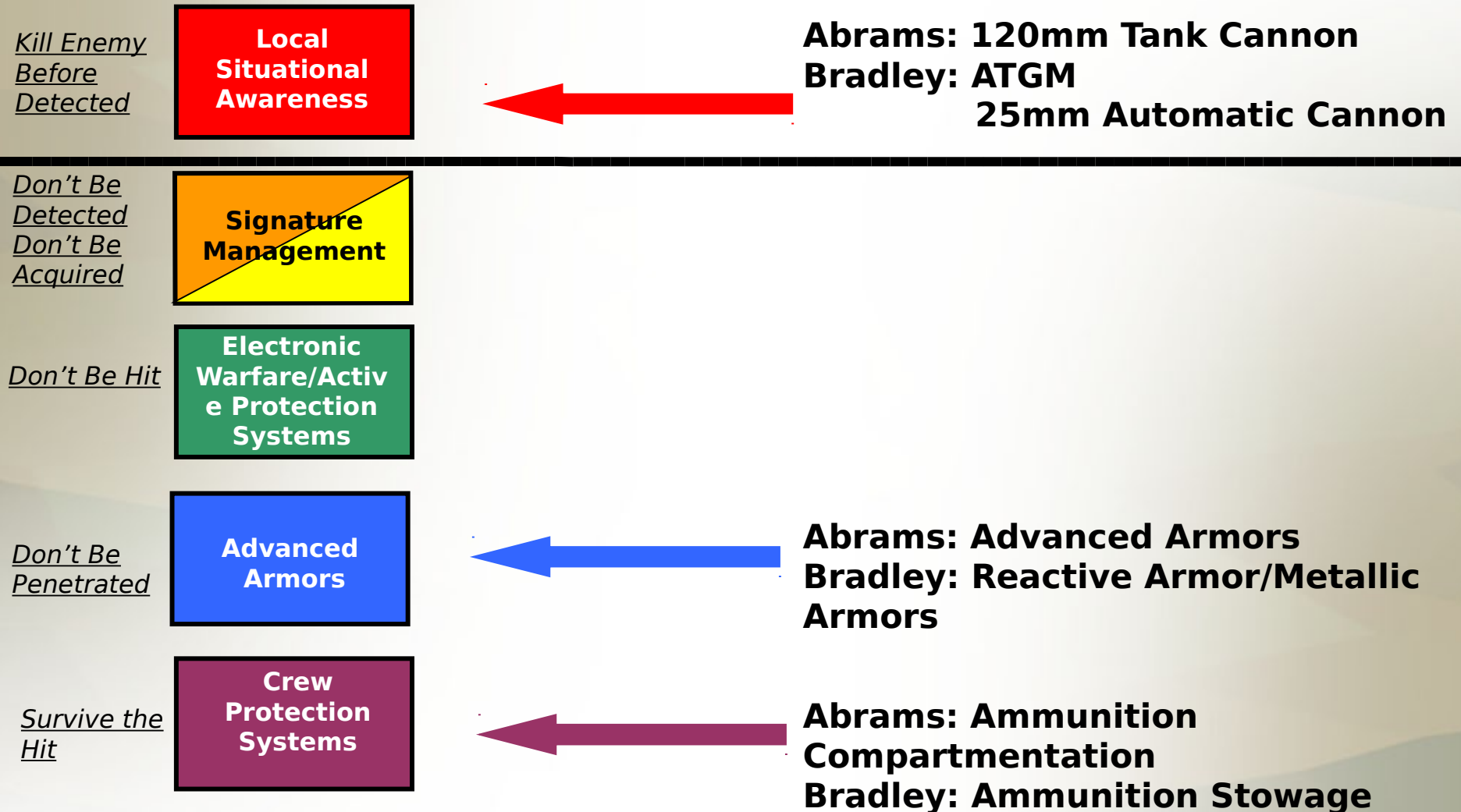
Iterate

Survivability Technologies

Integrated Survivability: Active and Passive Protection

Mike Zoltoski
Technical Director
US Army RDECOM-TARDEC

Baselines: Abrams / Bradley Fighting Vehicle



An Integrated Protection Scheme

AP/EW

Large KE *Divert*
ATGMs *Breakup*
Large HEAT
RPG

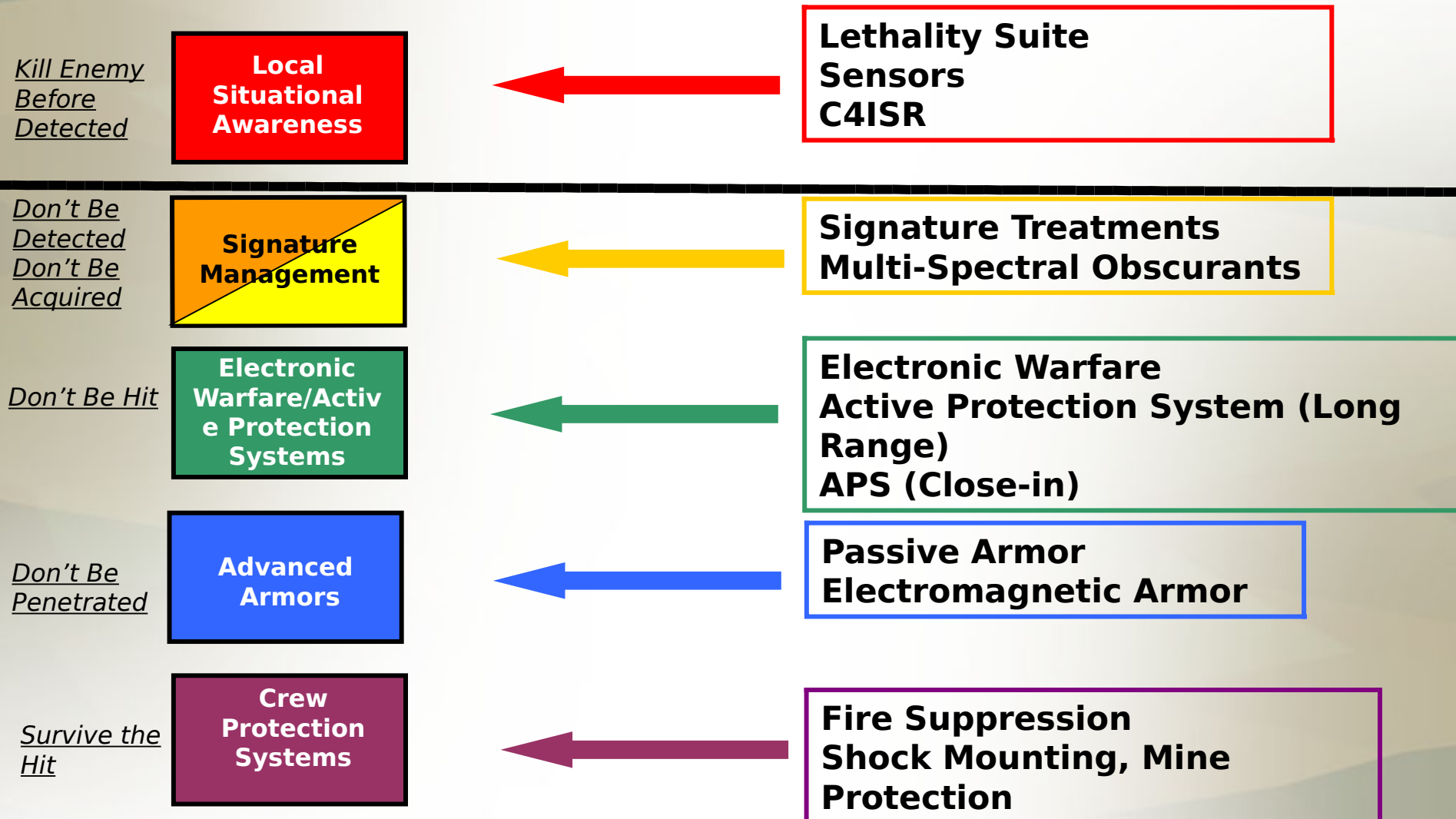
Sensor-Fused
Munitions



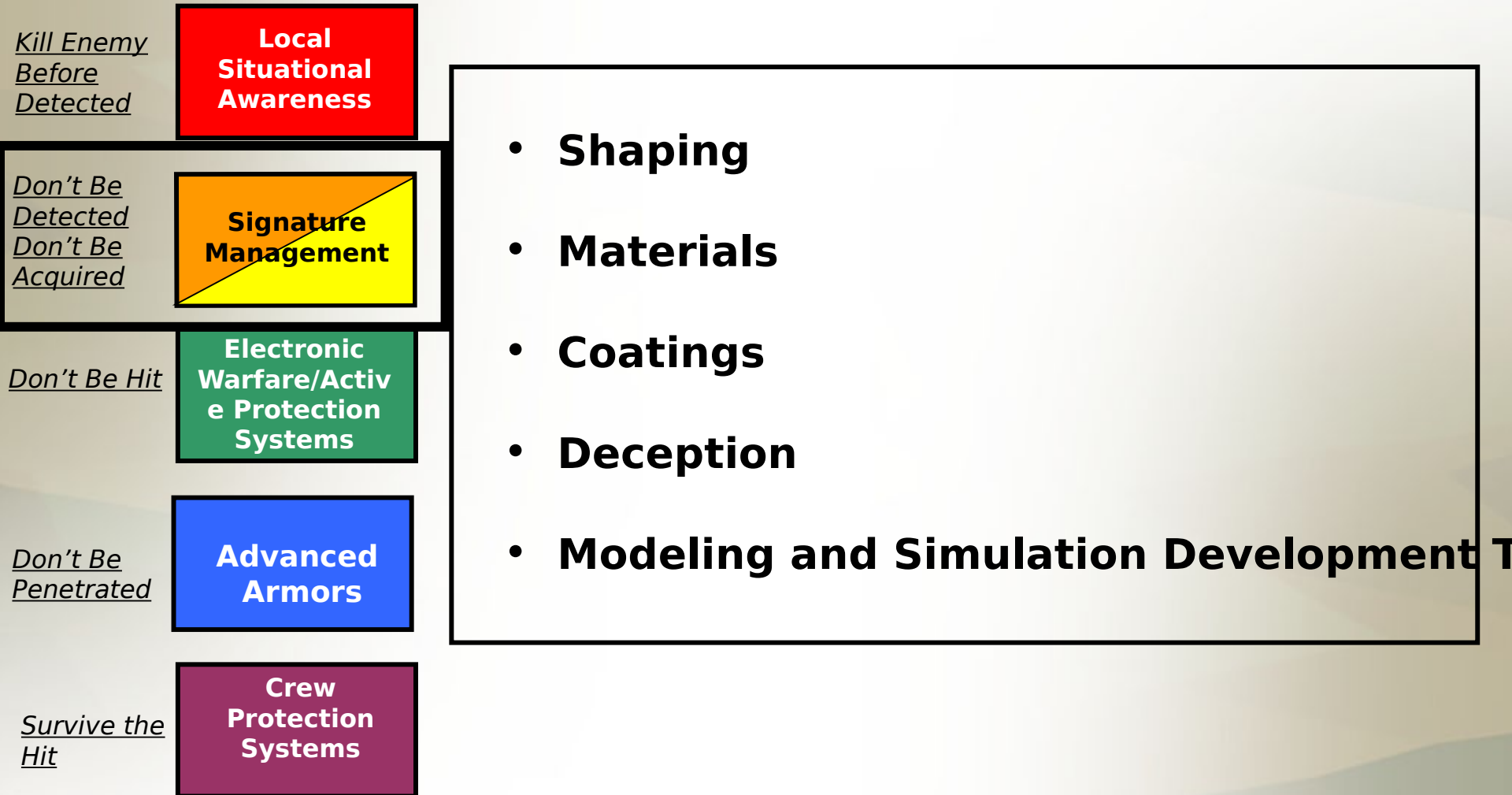
ARMOR

Medium Caliber KE *Frontal Arc*
Residual KE Debris
Residual CE Debris *Side/Top*
RPG
DP-ICM
Heavy Machine Gun *Rear*
Fragments/Blast
Mines

Future Integrated Survivability



Detection Avoidance - Signature Management



Active Protection/Electronic Warfare

Kill Enemy
Before
Detected

**Local
Situational
Awareness**

Don't Be
Detected
Don't Be
Acquired

**Signature
Management**

Don't
Be Hit

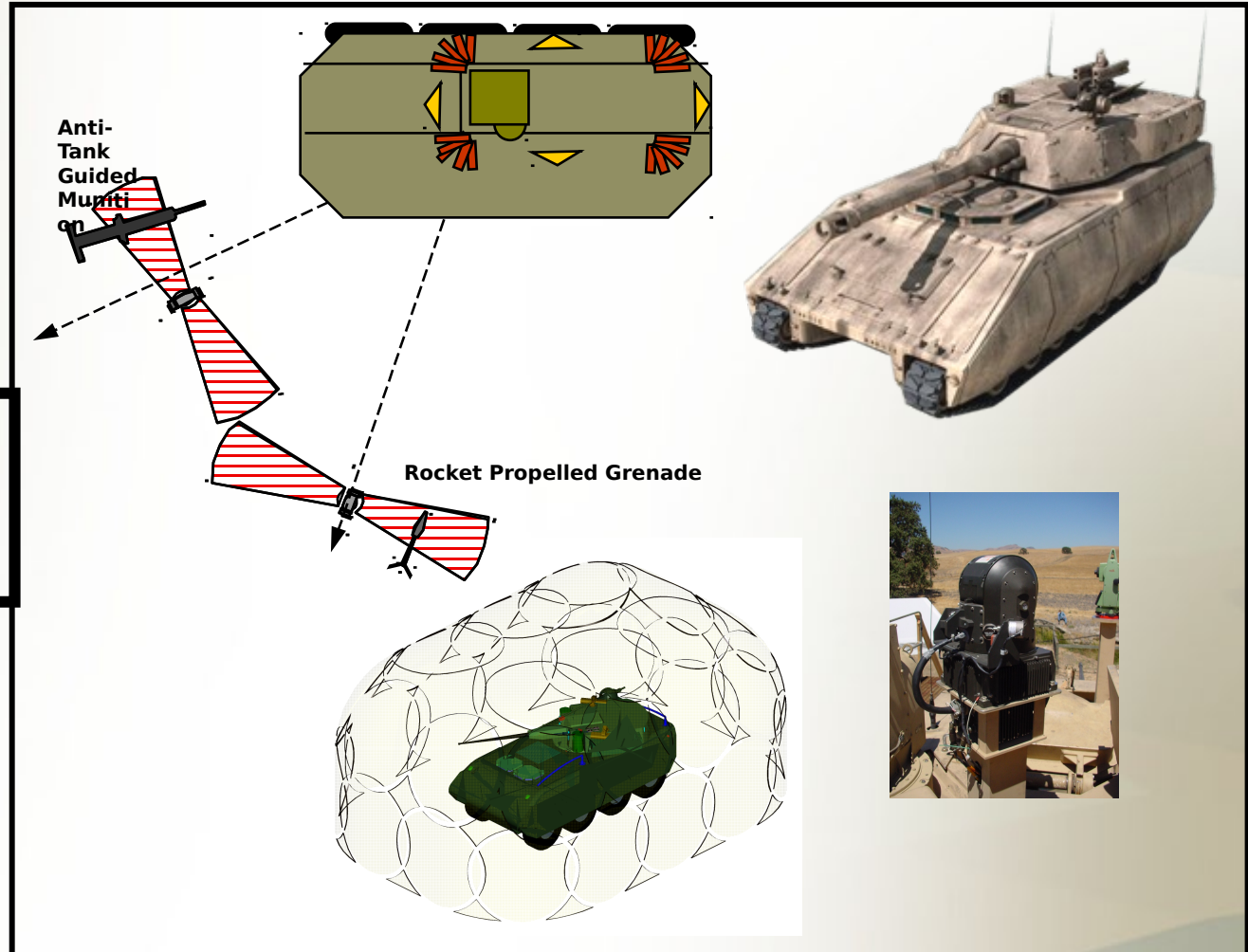
**Electronic
Warfare/Active
Protection
Systems**

Don't Be
Penetrated

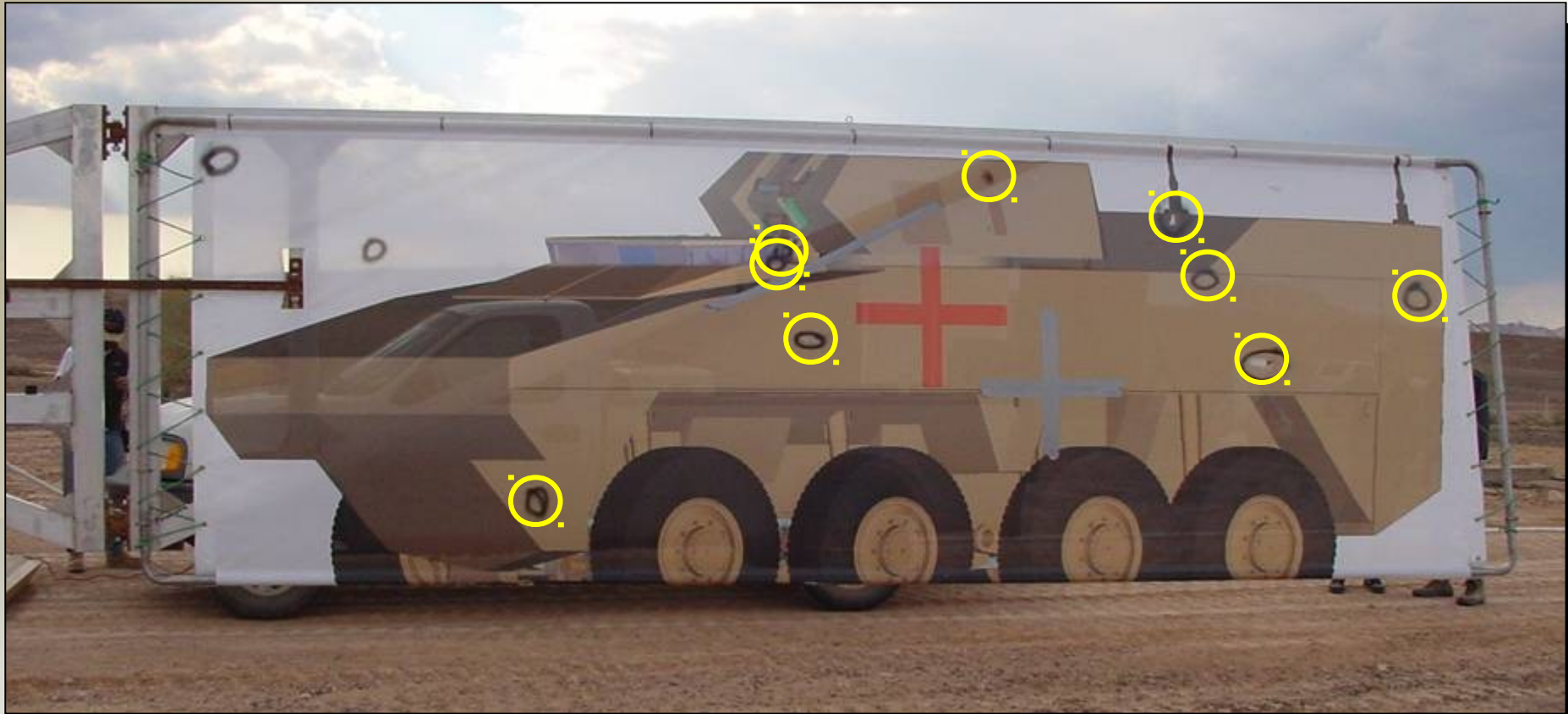
**Advanced
Armors**

Survive the
Hit

**Crew
Protection
Systems**



Residual Hits on the Silhouette



Tank Fired KE Defeat



Advanced Armors

Kill Enemy
Before
Detected

**Local
Situational
Awareness**

Don't Be
Detected
Don't Be
Acquired

**Signature
Management**

Don't Be Hit

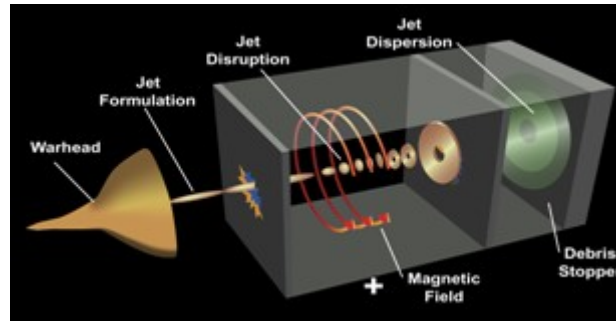
**Electronic
Warfare/Active
Protection
Systems**

Don't Be
Penetrated

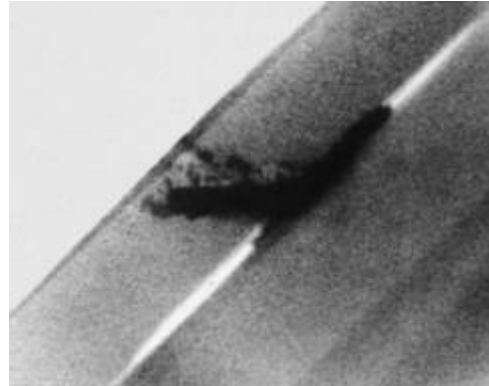
**Advanced
Armors**

Survive the
Hit

**Crew
Protection
Systems**



Electro-Magnetic Armor



Ceramic Armor



**Advanced Composite
Structural Armor**

Crew, Component, and Structure Survivability

Kill Enemy
Before
Detected

**Local
Situational
Awareness**

Don't Be
Detected
Don't Be
Acquired

**Signature
Management**

Don't Be Hit

**Electronic
Warfare/Active
Protection
Systems**

Don't Be
Penetrated

**Advanced
Armors**

Survive the
Hit

**Crew
Protection
Systems**



- **Mine Protection**
- **Fire Protection**
 - **Ammunition (Completed in FY02)**
 - **Petroleum, Oil, Lubricants**
 - **Advanced mobility components**
- **Ballistic Shock**
 - **Structure, Substructure, Components**

Summary

Critical Survivability Technologies

- Signature Management
- Hard and Soft Kill
- Armor
- Crew/Component Technologies

FCS manned ground combat vehicle
survivable on the modern battlefield

PM Lethality Systems' Integration

Pete DeMasi
Deputy Project Manager
Lethality Systems' Integration

Purpose



**To Present Lethal and Non-Lethal
Opportunities to Industry**

Agenda

- Key Decisions/Recommendations
- Potential Opportunities
 - NL Ammo
 - Non-Lethal Trade Results
 - 30mm Ammunition
 - 120mm Ammo
 - AKE
 - LOS-MP
 - MRM
 - 120mm Mortar Tube and Breech

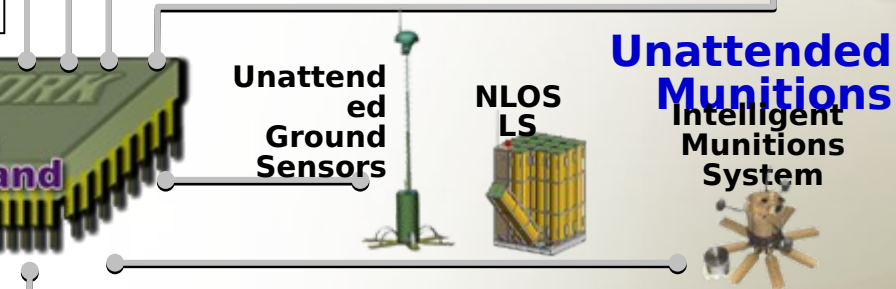
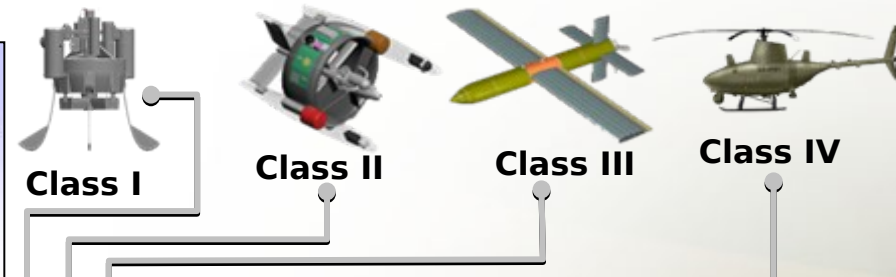
FCS Increment 1, Lethality Recommendations

Manned Systems

Unmanned Air Vehicles

Unattended Munitions

Unmanned Ground Vehicles



Key Lethality Decisions

Non-Line of Sight Cannon (NLOS-C)



Excalibur



- 155mm, 38 Caliber Cannon
- Excalibur

Non-Line of Sight Mortar (NLOS-M)

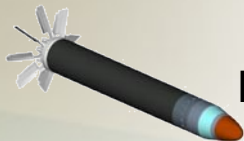


PGMM



- 120mm Turreted, Breech-loaded Mortar
- Precision Guided Mortar Munition (PGMM)

Mounted Combat System (MCS)



MRM



- 120mm Caliber
- Mid-Range Munition (MRM)

Infantry Fighting Vehicle (ICV)



- MK44 (30mm system, growth to 40mm)
- M240 7.62mm MG

Common Close Support Weapon (CCSW)



- XM307 25mm (Defensive armament for C2V, RSV, MCS, NLOS-C, NLOS-M, FRMV, ARV(A)-L and ARV-RSTA)

Non-Lethal Trade Background/Objectives



■ Background

- FCS ORD contains requirements for Non-Lethal Weapons (NLW) capabilities for FCS MGVs, UGVs and IMS
- A study is on-going to determine how these ORD requirements can be met across FCS FoS

■ Objectives

- Determine the best NLW for the FCS FoS consistent with meeting the ORD requirements, integration, cost and risk
- Determine a strategy for implementing these NLW on the

FCS FoS

- Develop a NLW roadmap including technology, integration, cost and schedule for implementing the strategy
- Focus development of technology to feed NLW into the FCS FoS

FoS Non-Lethality Requirements

- The FCS FoS must be capable of Joint networked lethal and non-lethal effects that achieve overmatch – out of contact and in contact, at tactical standoff and in close combat.
- The FCS FoS must employ non-lethal effects in a complementary manner (lethal effects combined with non-lethal effects) to enhance combined-arms effectiveness across the spectrum of conflicts, day or night.
- Delivery means will include Soldier emplaced, LOS, BLOS, NLOS, and UMS.

MGV Non-Lethality Requirements

- FCS Manned Systems (with the exception of MV-E & MV-T, ICV & R&SV) must conduct day/night and adverse weather engagements while stationary or on the move with a common close support weapon.
- Effects are scalable from lethal to **non-lethal**. This weapon system will be capable of firing multiple types of ammunition: anti-personnel, armor piercing, area effects, incendiary, **non-lethal**, and tracer from a common dual-fed magazine (selectable by the crew) with a selectable default setting.

UGV Non-Lethality Requirements

The FCS ARV (all) must be able to employ modular non-lethal capabilities to:

- (1) confuse and deceive the enemy as to our intentions by obscuring our force and intentions, screening friendly force movements, and illuminating and exposing target areas hidden by darkness
- (2) flush out the enemy
- (3) deny people access to or movement through a particular area/point/facility
- (4) deny vehicles access to or movement through a particular area/point/facility.

The SUGV must be able to employ non-lethal projectiles, obscurants and distraction devices, malodorants, riot control agents, electricals and markers specific to the MOUT environment.

Non-Lethal Trade Interim Results

FCS Vehicles	ORD Non-Lethal Requirement	SDD-168 Recommended Non-lethal Solution
All MGVs with CCSW	CCSW non-lethal munition	XM307 25mm non-lethal airburst munition
ARV-As, ARV-RSTAs	Capability to: (1) obscure own force, (2) illuminate the enemy, (3) flush out the enemy, (4) deny people access, (5) deny vehicle access	Modified LVOSS Launch System
ICVs and R&SVs	ORD implies a non-lethal munition for MK44	Modified LVOSS Launch System
IMS	Array of non-lethal capabilities	Non-lethal omni-directional munitions: flash bang, RCA, and blunt trauma
SUGVs	Non-lethal projectiles, obscurants and distraction devices	Two modules: (1) non-lethal munitions module, (2) strobe light distraction module
NLOS-Ms	Special fires that provide non-lethal effects	Non-lethal 120mm Mortar Munition
NLOS-Cs	NLOS non-lethal delivery means	Non-lethal 155mm Artillery Munition
ARV-As BLOS	BLOS non-lethal delivery means	Non-lethal BLOS Round

Opportunities Exist for Non-Lethal Development in 25mm, LVOSS, 155mm Cannon and 120mm Mortar Systems

Advanced Crew Served Weapon System Description



Defensive Armament for:

- C2V
- MCS
- FRMV
- NLOS-M
- NLOS-C
- ARV-RSTA
- ARV A(L)

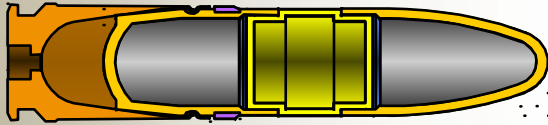
Supports FCS Defensive Armaments

- ✓ Minimal Interior Space Claim
- ✓ Light Weight / Low Recoil
Minimizes Mount Weight and Stabilization Requirements
- ✓ Dual Feed Capable
- ✓ Lethal 25mm Munitions
 - Air Burst Defeats Defilade Targets to 1,000m
 - Suppress and Defeat Area Targets to 2,000m
 - Armor Piercing Defeats Light Armor
- ✓ Muzzle Velocity Correction for Improved Accuracy
- ✓ Capable of Remote Operations
- ✓ Day/Night/All Weather Capable
- ✓ Fire on the Move Capable

Grenade Launcher Performance in a Light Machine Gun Package!

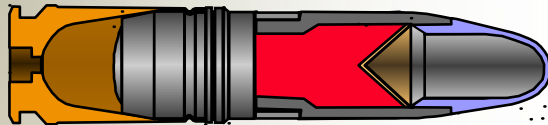
Advanced Crew Served Weapon System Description (Cont'd.)

HEAB Cartridge



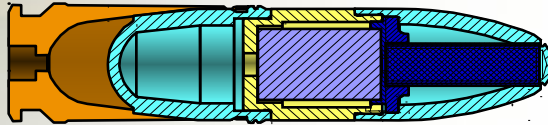
- HEAB Defeats Exposed and Defilade Targets
 - Precision Air-Bursting
 - Controlled Fragmentation Warhead

AP Cartridge



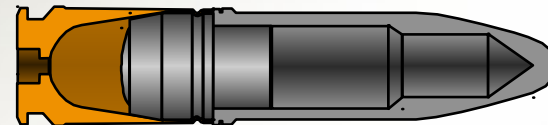
- AP Defeats Light Armor
 - Armor Piercing Shaped Charge Round

TP-S Cartridge



- TP-S Flash Bang Training

TP Cartridge

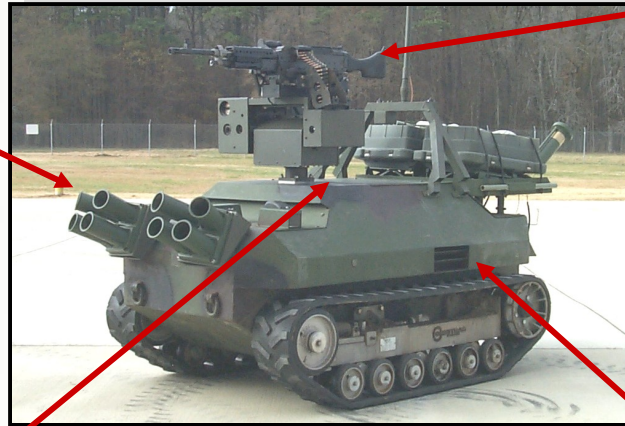


- TP Simple Two-Piece Projectile for Training

Potential Joint Non-Lethal Options for UGV's



66mm Non-Lethal Munitions / Dischargers



FN303



Existing Non-Lethal Capabilities w/ Conceptual Integration Locations on UGV



**Long Range Acoustic Device
(Hailing & Warning)**



Applicable to Other



M5, Modular Crowd Control Munition on VMS

XM1063 Non-Lethal 155mm Projectile



30mm Ammunition Requirements

- **Anti-Material**

- Defeat Threat LAVs (Light Armored Vehicle) with a single three round burst.

- **Anti-Personnel**

- Defeat Individual and Groups of Threat Soldiers with a single three round burst per soldier ,
- Group Targets include 2-man and 8 Man Squads.

30mm Gun and Ammunition Solutions

- 30mm Mk 44 Gun with AP (Armor Piercing) & AB (Air Burst) Rounds Meet FCS Requirements for Three Vehicles
 - Infantry Carrier Vehicle (ICV)
 - Armed Robotic Vehicle - Assault (ARV (A))
 - Recon & Surveillance Vehicle (RSV)
- Training Ammo for AP & AB Rounds also Required
- Marine Corps Qualified 30mm Rounds for EFV

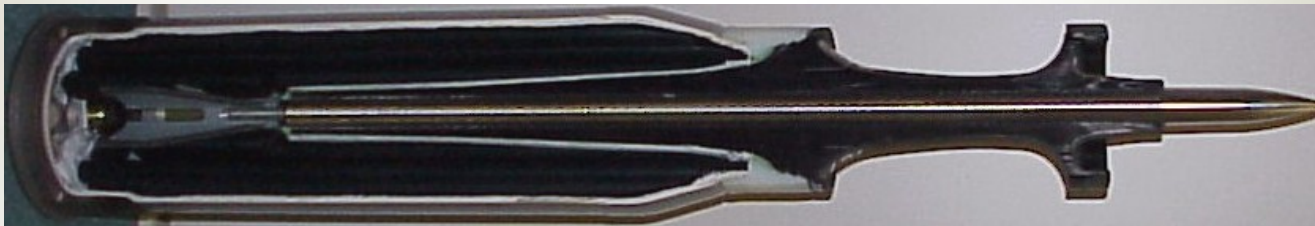
30mm Acquisition Approach

- **Qualify Marine Corps AP Rounds (FY04-FY06) to Meet FCS Anti-Material Requirements**
- Develop AB to Meet FCS Anti-Personnel Requirements (FY07-FY12)
 - Jointly Evaluate Industry Developed AB Round as a Possible Lower Cost NDI Alternative (FY05-FY06)
 - Pursue Best Solution
- **Qualify Marine Corp HE Trainer (FY04 - FY06) and NDI AP Trainer (FY09-FY12)**
- **Procure Beginning FY12:**
 - AP and AB Service Rounds
 - HE Trainer and AP Trainer

opportunities Exist for 30mm AB Development, NDI AP Trainer Qualification and Production of All Tactical and Training Rounds

120mm AKE Ammo

- Advanced Kinetic Energy (AKE)
 - There is a need for an MCS to be capable of firing unguided direct fire LOS munitions to defeat current and projected threat MBTs with Explosive Reactive Armor (ERA) and Active Protection Systems (APS)

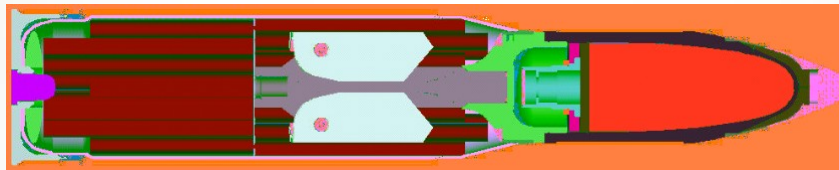


Opportunities Exist for Development (FY12- FY15) and Production (FY13-FY16) of an AKE 120mm Round

120mm LOS-MP Ammo

▪ **LOS (Line Of Sight) - MP (Multi-Purpose)**

- A moving or stationary MCS must be capable of firing munitions to defeat massed infantry or ATGM crews
- An MCS must fire munitions capable of breaching a 30" x 50" hole in bunkers and reinforced concrete walls



Opportunities Exist for Development (FY12- FY15) and Production (FY13-FY16) of an AKE 120mm Round

120mm Ammo

- Mid-Range Munition (MRM)
 - An moving MCS must be capable of firing guided Beyond Line-of-Sight (BLOS) munitions.
 - Draft RFP planned for FY07.



Opportunities Exist for Development (FY08- FY13) and Production (FY11-FY23) of a MRM 120mm Round

NLOS-Lethality Requirements

- FCS NLOS Mortar must be capable of LOS engagements for self-defense to destroy moving or stationary light armored vehicles.
- FCS NLOS Mortar must be capable of firing a 6 round Multiple Round Simultaneous Impact (MRSI) mission.
- FCS NLOS Mortar must be able to engage targets at ranges out to 8 to 12km.
- FCS NLOS Mortar must be capable of firing developmental munitions.

120mm Mortar Description

- Tube and Breech
 - NLOS-M cannon and breech subsystem
 - Fires current smoothbore/development
 - 120mm Mortar Ammunition/Propellant
 - Three meter tube (8 KM range)
 - Integrated with In Bore Air Regulation (IBAR) design
 - Automatic ammo handling system
 - Projectile retention system (low angle fire)
 - Breech automatic cooling system (high RoF)

120mm Mortar Acquisition Approach

- **FCS is procuring goods and services related to the engineering development of the NLOS-M Tube and Breech (*Best Value Assessment*):**
 - Engineering Development of Tube and Breech Assembly Integrated w/ ASD IBAR Sub-System
 - Test and CMP support
 - 4 Prototypes (Firing Platform, MEITS, & 2 Vehicles)
- **We are not procuring:**
 - Gun Drives
 - Gun Mounts
 - Recoil Mechanisms

These are common components with the NLOS-C.

- **RFP release in Nov 2005**

Opportunities Exist for 120mm Mortar Tube and Breech

120mm Mortar Ammunition Family of Extended Range Ammunition (FERA)



- The XM984 is a 120mm extended range mortar cartridge that provides extended range through the application of lightweight composite structural elements and post launch rocket motor impulse.
- PGMM Increment II currently has a requirement for extended range that would benefit from the application of lighter airframe components, rocket motor impulse and airframe shaping developed during the XM984 STO.
- PGMM Increment II can immediately leverage XM984 as a proven design.
- Range requirement for PGMM Increment II can be met through the application of a lightweight, high impulse, aluminumized rocket motor.

Opportunities Exist for 120mm Extended Range Ammo

Summary

- Key Decisions/Recommendations
- Potential Opportunities
 - NL Ammo
 - Non-Lethal Trade Results
 - 30mm Ammunition
 - 120mm Ammo
 - AKE
 - LOS-MP
 - MRM
 - 120mm Mortar Tube and Breech

Propulsion

Dean Vanderstelt
Director, Project Engineering
GDLS

Many Capabilities Demand Greater Electrical Power

Active Protection Systems

Radios & Sensors

Autoloader &
Ammo Handling

Cooling Fan

Active Track
Tensioner

Semi-Active
Suspension with
Height Control

Future Potential Capabilities

- Directed Energy Weapons
- Missile Loading and Launching
- More Advanced Electronic Warfare Systems
- EM Rail/Coil Gun
- Extended Duration Engine Off Silent

Electric
Drive
Propulsion

Crew Displays
and Controls

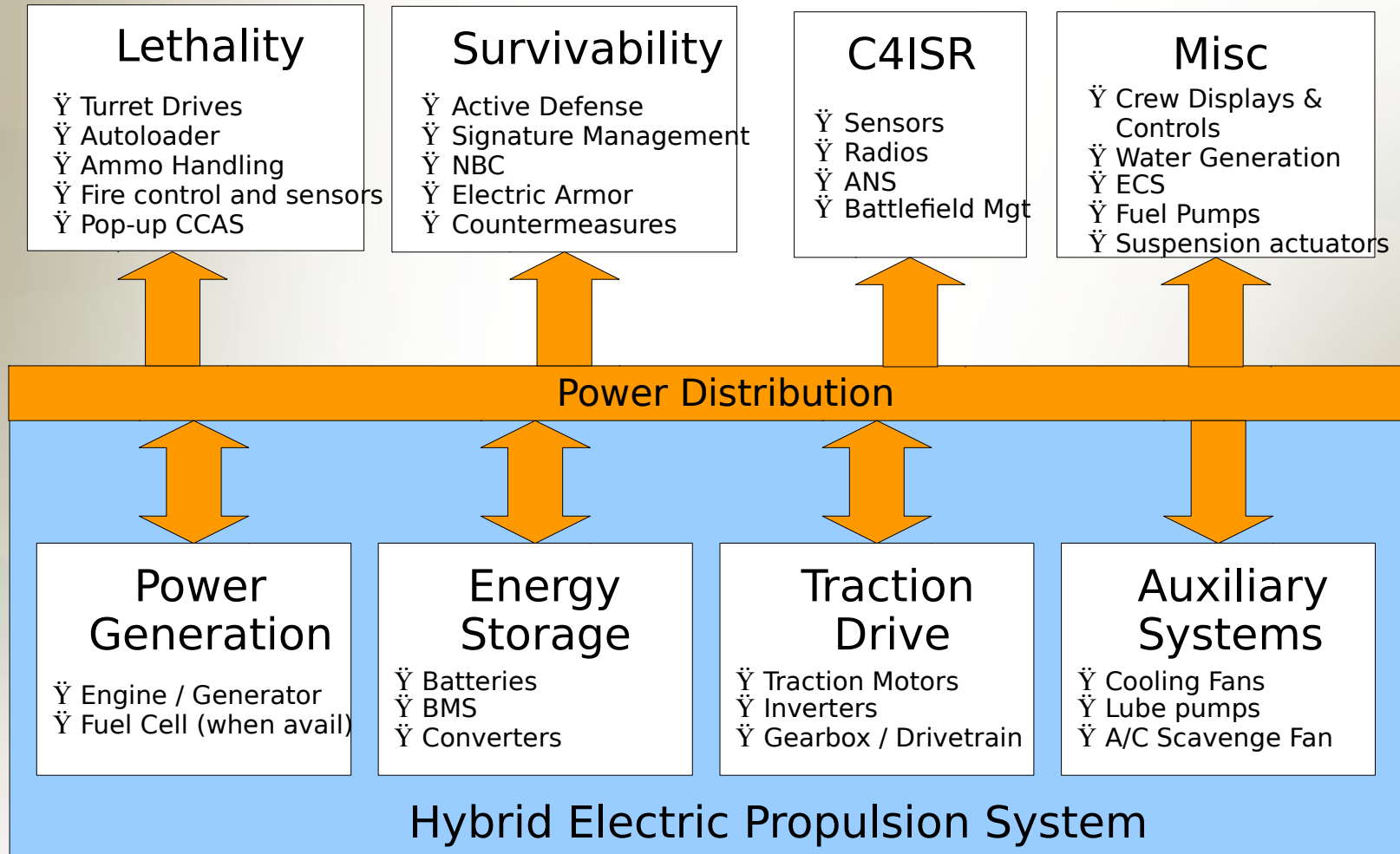
NBC /
ECS
Systems

Electrically
Enhanced Armors

Fire Control System & Turret Drives

A Robust Power & Energy Architecture is required to enable an all-electric vehicle with intelligent power management for greater mission effectiveness

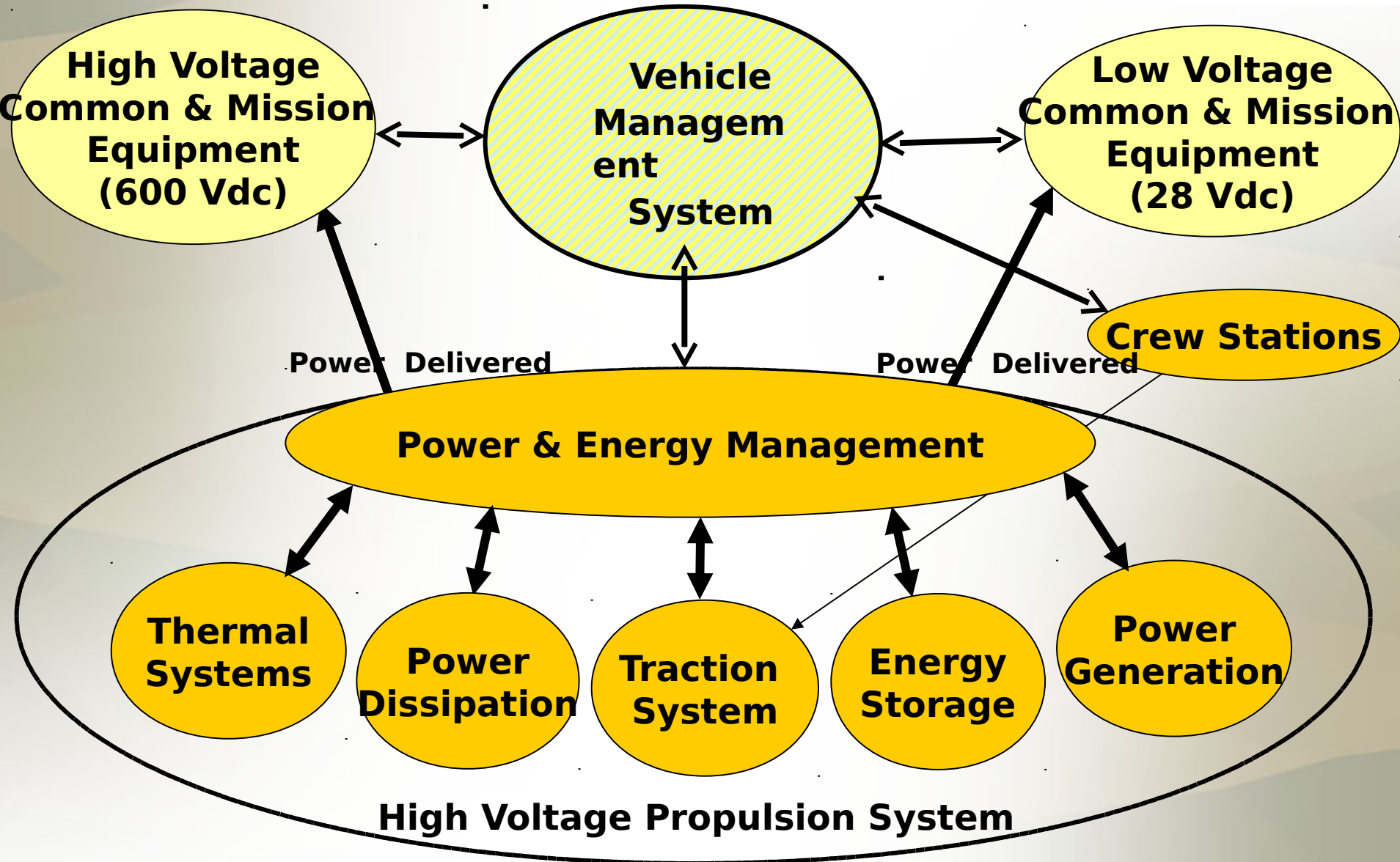
Smart Hybrid Electric Architecture Provides Power for All



System Architecture Tenets

- Develop a dynamically responsive system architecture for Manned Ground Vehicles that stresses the following:
 - Smaller Weight and Space/Volume than Current Force Vehicles
 - Commonality
 - Maximize software reuse / achieve resource optimization
 - Reduce hardware duplication among subsystems
 - Graceful System Degradation (Survivability/Reliability)
 - System/Subsystem Redundancy
 - Flexible and Adaptable Architecture
 - Implementation of Standard and Open Architecture Interfaces
 - Improved Performance

MGV Power & Energy Management Architecture



MGV Power and Energy Management Examples

- Examples of applied power and energy management:
 - Load prioritization and shedding directed through established protocol with Vehicle Management System
 - Battery power and cooling fan modulation during acceleration to minimize Power Generation and Thermal Management system size
 - Automatic Override of Component Protection Algorithms in Critical Combat Mode (Max Power even though Component temps are high)
 - Instantaneous power output plus power reserve will be managed to maximize responsiveness to changing loads (mode dependent)
 - Stored energy will be managed to maximize transient power needs (such as vehicle dash/survivability move) and

Mapping Mission Needs to Power and Energy Management

Mapping Vehicle Mission Needs to P&E Management Implementation

▪ Vehicle Mission Needs

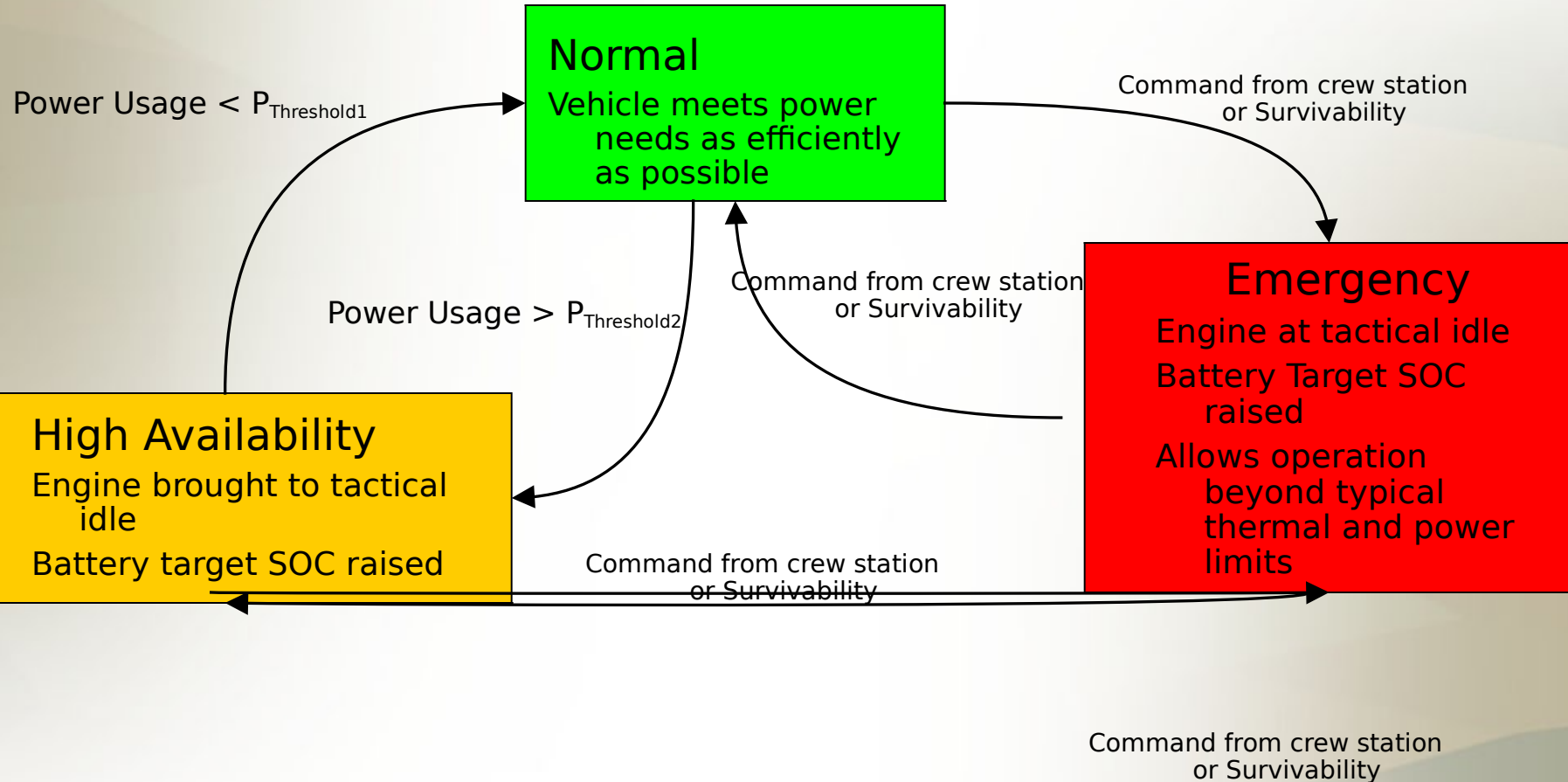
- Power Demands Established by Mission Needs
-
- Coordinate power usage and generation
- Optimize efficiency of power usage and generation
-
- Safety, protection and

▪ P&E Management Implementation

- Set Load Priorities
- Maintain reserve power
- Make load-shedding decisions
- Set target battery SOC (State-of-Charge) and engine speed
- Allocate power usage and generation to subsystems
- Optimize engine-generator, battery power split
- Manage battery SOC and engine-generator speed-torque maps
- Overcurrent, overtemperature, graceful degradation

Notional Power and Energy Management Modes Example

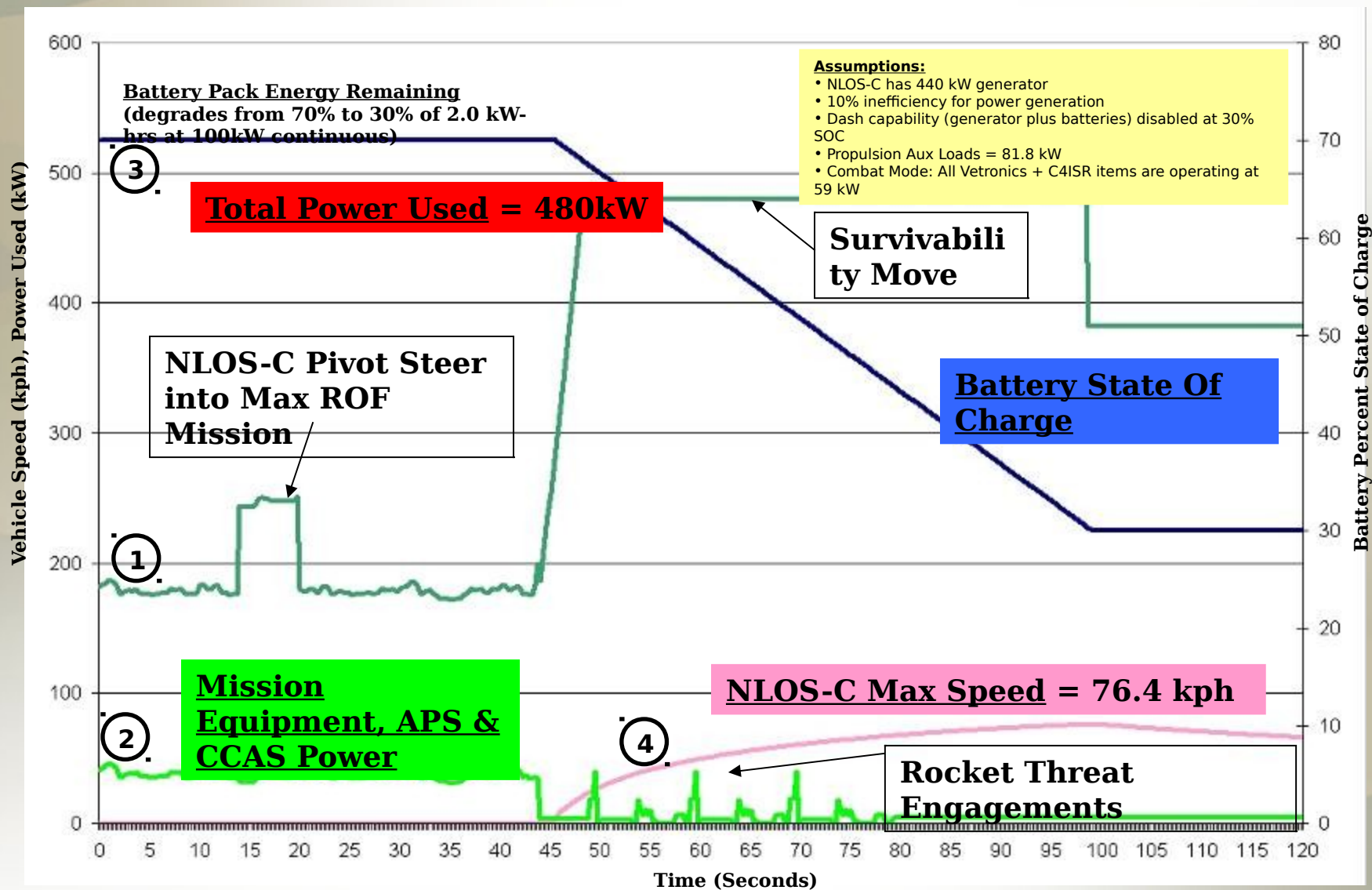
- Within Vehicle's Normal Operation/Combat mode
 - Power and Energy Management has three basic modes



Stressing Power Analysis Goals based on Mission Needs

- Develop a set of stressing power curves for each MGV Vehicle based on Vehicle Integrator generated **Design Reference Mission Profiles (DRMP)**
- Define the worst case scenarios and determine what it takes to satisfy the Requirements in terms of -
 - Power Generation and Energy Storage system rating (size)
 - Cooling System capability and size
 - Define the limits of up-powering to meet the mission profiles within the air transport envelope
- Determine if loading from Vehicle Mission events can be accommodated within acceptable degradation limits
 - Mission degradation will be assessed based on the ability to provide power based on the following priorities:
 - Survivability -> Communications -> Lethality (Or Unique Mission Need) -> Mobility -> Remaining loads
- Identification of acceptable power allocation and load shedding solutions for the highest total load scenarios to minimize overloading

MGV Stressing Power Scenario Example



Summary

- Mission equipment loads now represent a significant portion of the overall power loads for MGVs. → It's NOT just about Propulsion loads anymore!
- Transient power demands will be met by energy storage in order to reduce installed engine power, system volume and weight
- Addressing mobility demands, as well as other platform and mission demands, must be managed interactively to balance and prioritize all loads based on system and user defined priorities.
- Intelligent control of power sources relative to major loads maximizes mission effectiveness with minimum installed power
- MGV Power and Energy Management Architecture:
 - Modular, Robust
 - Flexibility - can implement wide range of techniques and strategies
 - Uses databus communication interfaces for real-time control
 - Accommodates future growth and development of both hardware and software

The FCS UA MGV Power and Energy Architecture is the Core Combat Power and Energy Design that meets the Army's needs for the 21st Century

Dean M. Vanderstelt
Director, Project Engineering

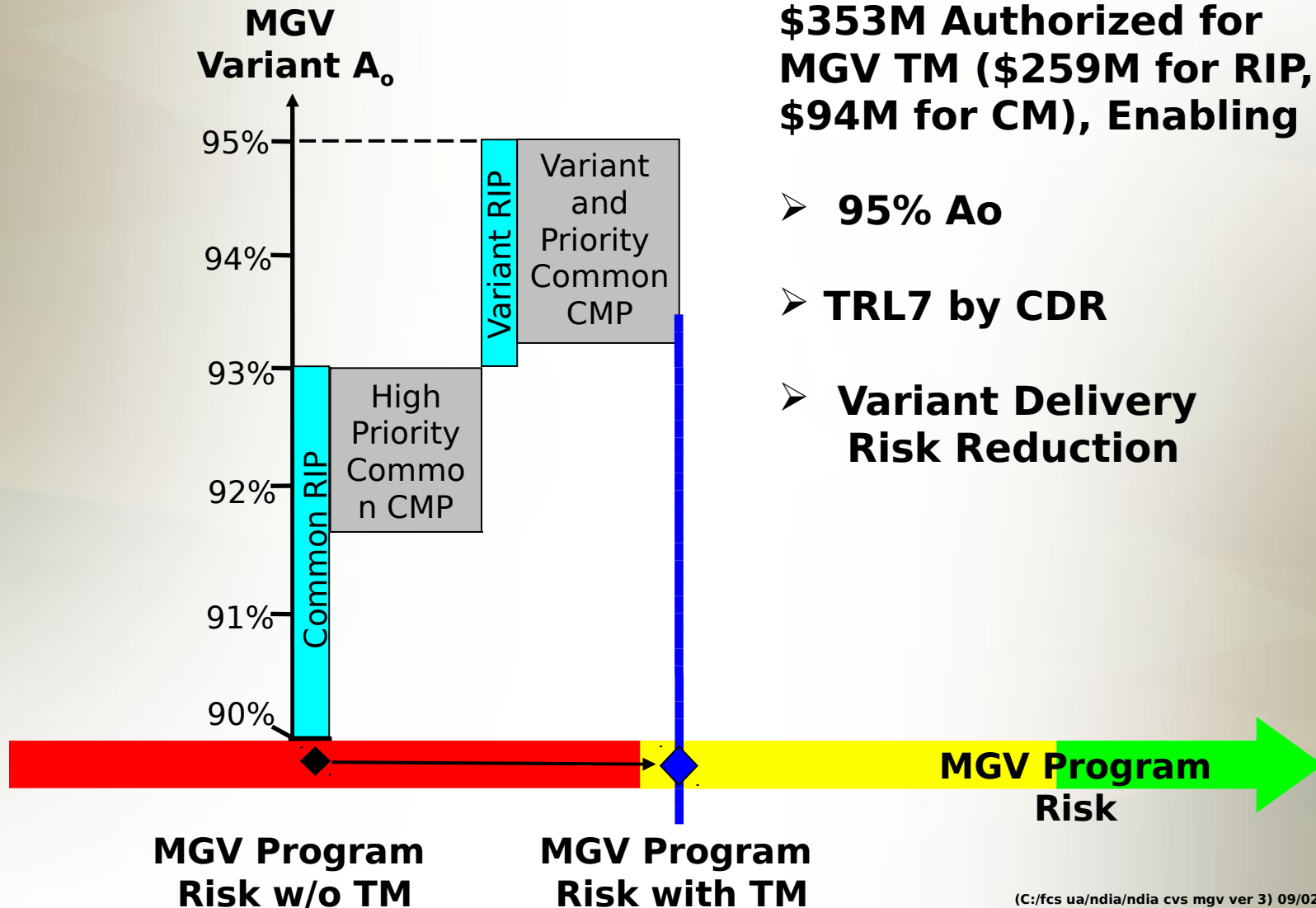
General Dynamics Land Systems
38500 Mound Road
Sterling Heights, Michigan USA
48310
586.825.7600 (Voice)
586.939.2655 (FAX)
vanderst@gdls.com

MGV Technology Maturation/Reliability Availability and Maintainability (RAM) Overview

Tom Hartigan
PM UA, MGV RAM-T Engineer

MGV Program Risk Assessment - Case For Tech Maturation (TM)

TM = Component Maturation Program (CMP) and Reliability Investment P



Component Maturation Projects

- Band Track Survivability, Performance, Durability and Sustainability
- Mine Resistant Structures
- Add-on Armor Recipes and Integration Approach
- Hi-Power LI-Ion Platform Energy Approach
- Generator/Inverter Power Stage Reliability
- Traction Drive Maturation
- Short Range Counter Measure Common Radar Integration
- Multimedia Slip Ring
- Rooftop Deconfliction/Integration (C2V and RSV)
- MCS Firing Test Rig
- MCS Ammunition Handling System (AHS)
- MCS High Voltage Electric Drives
- MCS Automated Fire Inhibit System (AFIS)
- MCS Dynamic Muzzle Reference Sensor System
- MCS Ammunition Data Link (ADL)
- MCS Ammunition Sympathetic Detonation
- FRMV Towing Capacity
- FRMV Tactical Crane System
- NLOS-M In-Bore Round Retention
- NLOS-M Propellant Storage and Handling
- MV MC4 Software

MGV Common Suspension Component Maturation Project

Title: Track Survivability, Performance, Durability, and Sustainability

Maturation Effort Description:

Conduct engineering and maintenance studies/demonstrations to develop improved track compositions which will ensure increased survivability, mobility, sustainability and operational availability (A_0).

Consequence Of Not Funding Maturation Effort:

Current reduced durability causes degraded mobility performance, operational availability (A_0), and increases the logistics burden. Without enhanced mine blast resistance crew survivability will be diminished. Lack of track segmentation leads to increased utilization of the Combat Repair Team (CRT) which increases the Logistics burden.

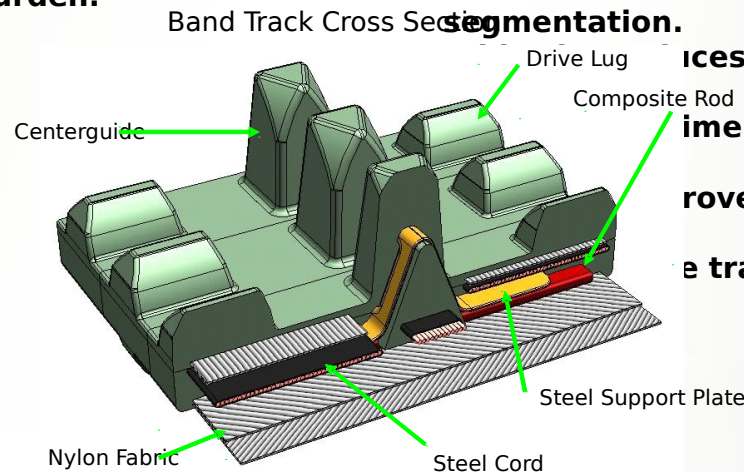
Rationale:

- Enhanced durability is needed to meet FCS-MGV requirements and will reduce the track Life Cycle Cost.
- Increased mine blast resistance is needed to meet FCS - MGV requirements
- Increased mobility is required for FRMV.
- Track segmentation is required to meet reduced Logistical burden through less frequent use of the Combat Repair Team.

Performance Improvement:

- In terms of mileage, the plan establishes a 2000 - 3000 mile goal for the track vs. the 400-500 miles demonstrated during the CTD phase on 22 ton platform.
- Reduce the installation time for the track by segmentation.

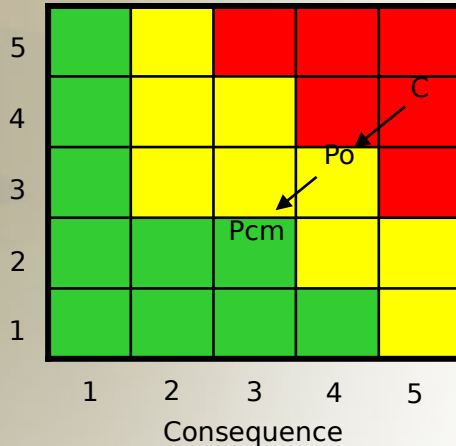
ices the equipment needed for
ime should be reduced to below 30
rovement in mine blast resistance
e track.



MGV Common Suspension Component Maturation Project

Title: Track Survivability, Performance, Durability, and

Sustainability



Driving Requirements:

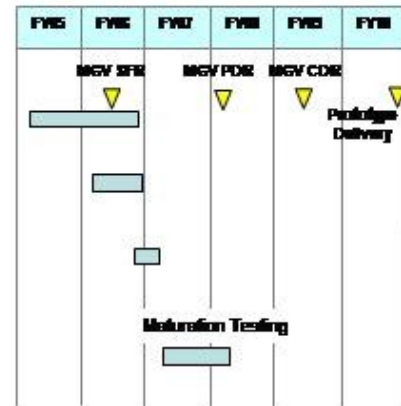
- 3.1.2.2.13.1.0-5 Mine Blast AT mine
- 3.1.2.2.1.3.4.0-1 & 0-2 Mine Blast AP mine
- 3.1.17.1.8.0-7 & 0-8 Wear Replacement

Contingency Plan:

- Failure to successfully mitigate this risk will:
 - Cause there to be inadequate survivability in the band track
 - Not address the current maintenance issues raised by the RAM team
 - Not incorporate necessary improvements needed to increase durability, survivability and maintainability.
- Fallback is to
 - Accept current survivability and maintenance of existing band track configuration or
 - Use heavier weight metallic track, but be faced with needing to accept the system weight impact and reduced mission capability

Mitigation Steps and Schedule:

1. Design, analyze, simulate, and select survivable, durable, sustainable segmented track configurations.
2. Develop processes / tooling for high quality manufacturing.
3. Manufacture prototypes for tests: mine blast / KE, mobility/ traction, durability, joint tests, and sustainability demonstrations
4. Maturation T& E: survivability, performance, durability



Total Approved Funding Allocation = \$10.5M

Funding Allocation By FY (\$M):

FY05	FY06	FY07	FY08	FY09
0.71	2.41	6.66	0.72	0

Related Gov't Work: TARDEC program to develop segmented rubber track.

The FCS Family of Systems (FoS) is required to have a reduction in maintenance and supply functions and a reduced logistics' burden for the Unit of Action (UA)

- Rationale:
 - FCS-equipped Unit of Action characteristics of tactical dispersion and rapid offensive maneuver over tactical and operational distances demand superior FCS FoS reliability, availability, and maintainability (RAM) and reduced external resupply of the UA.
 - Cornerstone enabling capabilities include increased operational availability [measured by mission defined critical systems, greater than 85% (Ao) threshold, 99% (Ao) objective], reduced maintenance ratios [less than 0.10 threshold, 0.025 objective] maintenance man hours to operating hours (MMH/OH) and an objective of reduced fuel consumption, and on-board water generation.
 - Supporting enablers include component commonality, embedded diagnostic and prognostic systems, and rapid component replacement.

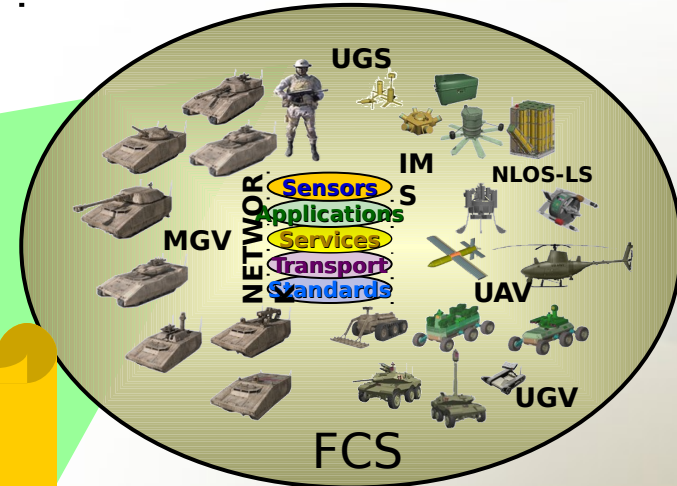
The FCS program will exceed RAM-T thresholds

FCS Calls for Quantum RAM Improvements

Lessons Learned

MGV Reliability
Performance
(MTBSA) Will Be
2 to 8 Times Better
Than Previous
Platforms Examined

Key Enablers:
The RAM-T Case Approach
Physics of Failure (PoF)
Reliability Enhancement Testing (RET)
Prognostics
Probabilistic Design Analysis
Integrated Design Process for Maint.



MGV MR Performance
Will Be 2 to 4
Times Better Than
Previous Platforms
Examined.

Early Design Influence

Early Program Resource Commitment is the Key!



FCS Contracting Approach to RAM-T

- The RAM-T Case Plan and Report contains the evidence to establish confidence in achieving the stated R/M requirements.
- Evidence that the three objectives have been met from all suppliers
 - Understanding the Requirements
 - Planning & Implementing a Program of Activities to Satisfy the Requirements
 - Assurances that the Requirements are being/have been met – Progressive Assurance
- RAM-T CASE Management Plan and RAM-T CASE Report
 - Key Supplier Deliverables
 - Case Report submission varies by supplier
 - Regular discussions through RAM Meetings/TIMs

RAM-T CASE PLAN specifies a number of tools and methodologies to use and rationale as whether they will or will not be used.

- Some of the techniques called out in the SDRL:
- Dynamic/static design modeling, simulation, or probabilistic analysis
- RAM-T Modeling, Optimization and Component/System Testing
- Environmental stress (operate and storage)
- Physics-of-Failure (PoF)
- Structural finite-element stress analysis
- Fatigue analysis
- Wear-out/service life analysis
- Prognostics analysis
- Fault detection/isolation analysis
- Availability Analysis
- Reliability Enhancement Testing (RET)
- Pit Stop Engineering
- Software Reliability

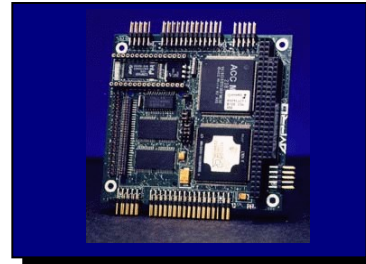
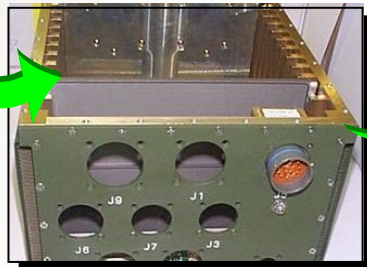
Physics of Failure (PoF)

Physics of Failure

- Early Design Influence through Physics-based Modeling of Critical Component Designs
 - Model the root causes of Failure
- Probabilistic approach to Modeling - Address Uncertainty
 - Allows for Design Optimization
- Modeling builds up to a Vehicle-Level Dynamic Simulation.
- Feeds directly into a Virtual Development Approach
- Robust Failure Models & CAD Tools

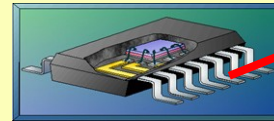


Stress (e.g., vibration) is propagated from system level to failure site

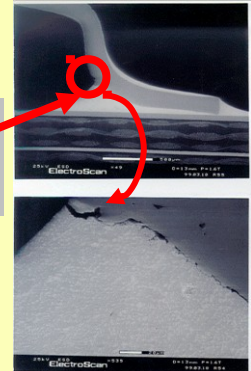


Benefits

- Increased Fielded Reliability
- Reduced Log Footprint
- Reduced Maintenance Ratio
- Improved Prognostics
- Decreased O&S costs



Root-cause failure is cracking of solder joint



Key Contributor to Increased Ao

Reliability Enhancement Testing (RET)

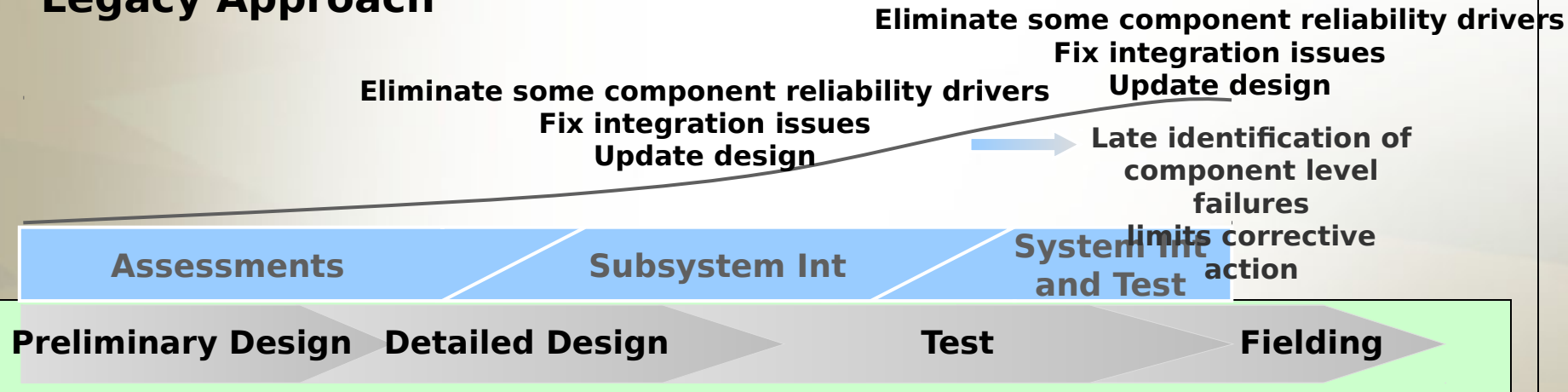
- Reliability Enhancement Testing
- RET = Accelerated Life Testing (ALT); Highly Accelerated Life Testing (HALT); Highly Accelerated Stress Screening (HASS) - component/subsystem testing in highly accelerated environments to shake out additional failure modes
- Destructive test which incrementally increases environmental stresses to determine Failure Modes - Find Design Faults
- Test, fail, and corrective action prior to prototype integration, to prevent possible field failures
- Not a compliance test, and is not limited by component or product specifications
- Applied at multiple levels - Components, LRU, Subsystems

Benefits

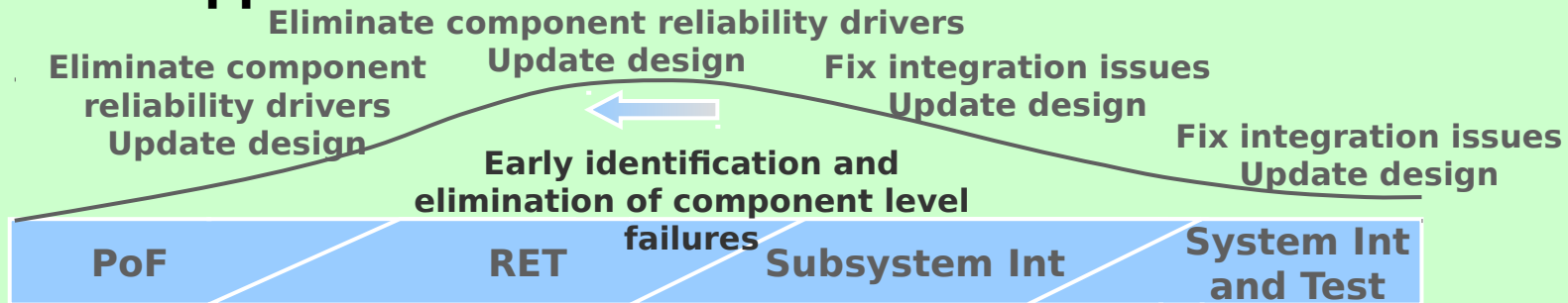
Rapid design and process maturation
Higher MTBF
Reduced total engineering time and cost
Minimize costly failures during system testing
Greatly reduced manufacturing screening costs
Reduced production and warranty costs

The New RAM Design Paradigm

Legacy Approach



MGV Approach



Emphasize: Early identification and elimination of failure modes
Achieve: Higher Initial Reliability (Mi) on prototype delivery

Reliability Investment Plan (RIP)

- Background
 - Baseline Contract - Dec 2003 based on MTBSA of 350-500 hours per variant, excluding GFE/CFE
 - Constrained by schedule and budget
 - Estimated platform Ao of 86-90%
 - Increased Log Footprint burden on UA
 - Unacceptable to User
 - When FCS Transition came about the TRB saw a need for increased reliability investment
 - A Wedge of Money was fenced for Technology Maturation (TM)
 - TM = Component Maturation + Reliability Investment Plan (RIP)
 - MGVS Reliability Investment Review Board of Govt/LSI SMEs evaluated VI RIP and provided recommendations to TRB for Approval

**RIP Investment supports achievement of 95% Ao for MGVS
And enormous LCC savings for the Army (~\$21B)**

RIP Analysis Approach

- Focused on Failure Mode Mitigation Prior to Integration Test
 - PoF- Physics-based modeling and simulation on all critical components and components which drive essential functions and log burden, to include FEA, fatigue, thermal, shock, vibrational analysis, dynamic modeling
 - RET - Reliability Enhancement Testing is conducted at component, LRU and subsystem levels to drive out additional failure modes and push the performance envelopes of the hardware.
 - Prognostics for Failure Avoidance through investments in establishing key performance characteristics, developing algorithms, testing to collect data points, and building sensors.
 - Probabilistic Design Analysis to model the probabilistic variability of design characteristics
 - Benchmarking to evaluate existing Army and industry data on like systems components and functions.
 - Consulting from industry experts in PoF, RET and PDA, including outsourcing of selected analyses.

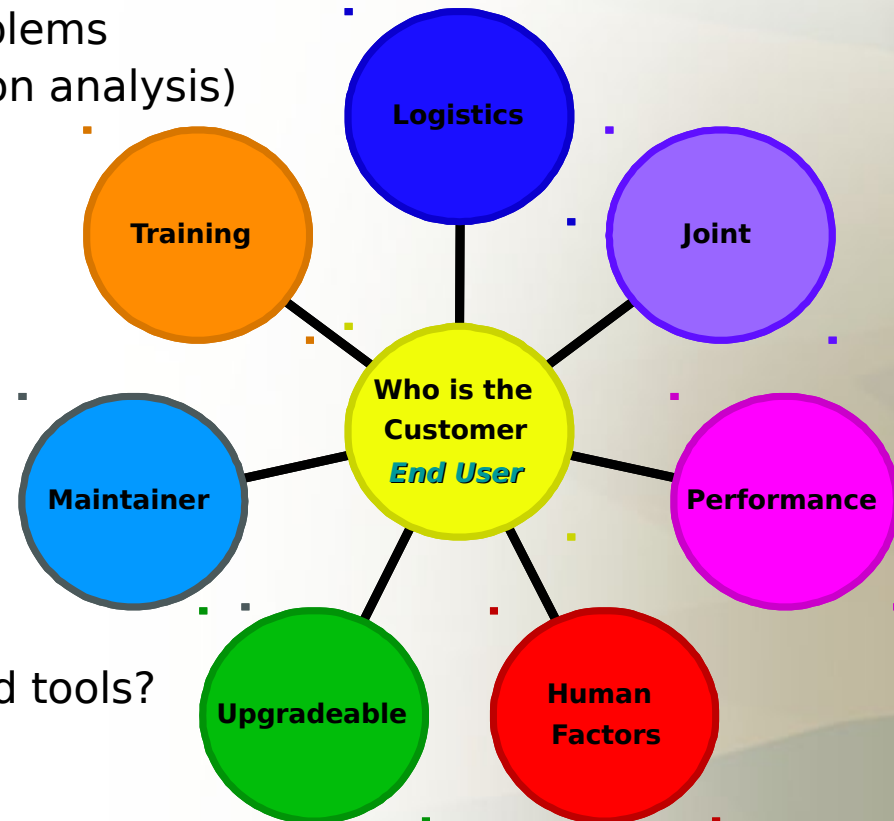
**Most Funding available for execution
prior to MGVCDR (for design influence)**

Early work will focus on Common subsystems and NLOS-C for Increment 0

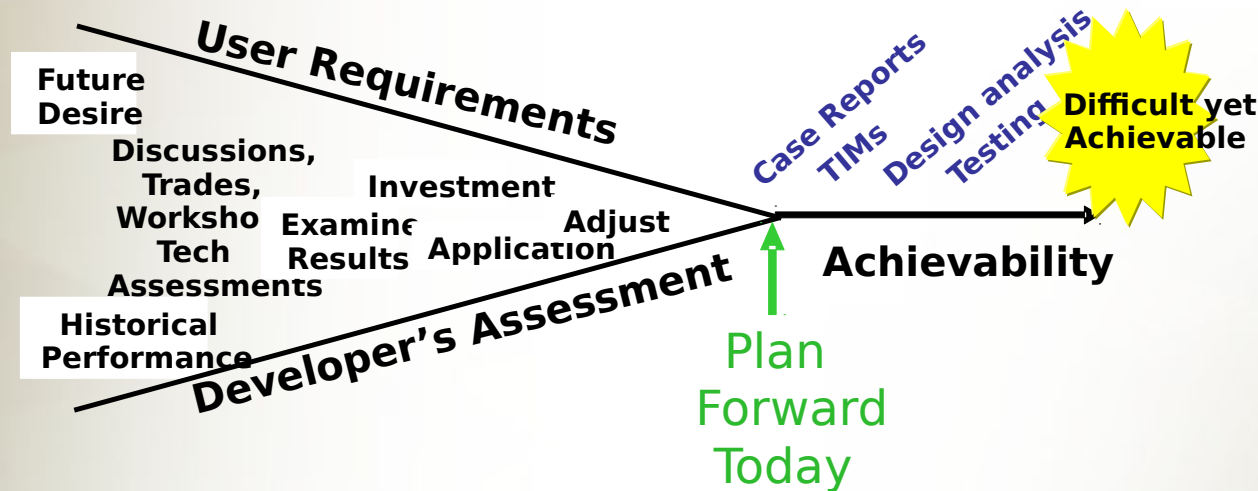
\$50M Award Fee available for exceeding requirements

FCS MGV Maintainability Design Influence

- Concurrent Engineering through Integrated Design Teams
 - Process has been documented as a System Engineering process
 - Multi disciplined walk-through of focus areas with designers
 - Based on Carlson's Pit-Stop Principles
 - Begins with sub-allocation of requirements
 - Identification of worst case access problems
 - Maintenance task analysis (using motion analysis)
 - Challenge the designers with time allocations (for MTTR)
 - 10 minutes to access
 - 15 minutes to remove/replace
 - Assess Crew repair capability with questionnaire to address MaxTTR and 80% Crew Chief requirement
 - Is a lift required?
 - Is task described in IETM?
 - Can it be done with the 10 on-board tools?
 - How often will it fail?
 - Etc.
 - Reevaluate metrics (TTR) after redesign



Summary



- FCS Requirements have converged based on need and capability
- FCS MGV RAM requirements are challenging but achievable given our present cost and schedule
- Primary emphasis in early design influence for little “m”, big “R”.
- FCS did it right!...and committed the resources to design influence
 - *Implementing the RAM-T Case Approach*
 - *Component Maturation focuses on high risk technologies*
 - *Focus is on failure mode mitigation through PoF and RET*
- This investment will yield a highly force effective and lower logistic footprint fleet through high Ao, low MR and plug and play

Early Program Resource Commitment => \$21B in LCC Savings